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REVUE AGRICOLE Vol. XXIII, No. 3 (Mai Juin 1944)

Standardization of Chemical Control
E. HADDON

P. 101 — line 12 *read* 13.25 *instead of* 13.34
,, — line 14 *read* 0.09 *instead of* 0.06
P. 101 — line 22 below 11.49 *read* Published figures 11.55

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The Presence of Sulphurous and Sulphuric Acids in Distillery Products.
S. STAUB

P. 158 — line 4 *read* 65 mgs. *instead of* 55.

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LA REVUE AGRICOLE

DE

L'ILE MAURICE

RÉDACTEUR : P. O. WIEHE

SOMMAIRE

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NOTES ET COMMENTAIRES

Ce numéro de la Revue Agricole est consacré comme tous les ans à la publication des conférences organisées par l'Association des Anciens Etudiants du Collège d'Agriculture. Trois sujets d'intérêt d'actualité y sont discutés : la dissertation de M. Pierre Halais sur le diagnostic foliaire ouvre des horizons nouveaux dans le domaine agrobiologique et économique. La discussion du mémoire de M. C. R. Harrison sur la malaria offre des aspects pratiques du contrôle des moustiques dont dépend dans une grande mesure l'avenir de notre pays. La conférence du Docteur Wheeler sur certains problèmes connexes à l'industrie de la pêche a été un modèle de la méthode scientifique. Faute de place les conférences de M. André Martin et du Docteur Philippe Cantin ne pourront paraître dans cette livraison de la Revue Agricole.

La Revue Agricole souhaite la bienvenue à M. Jean Carles, G.I.E.E., M.I E.T. lauréat du Collège d'Agriculture en 1939 qui est revenu récemment pour occuper un poste dans le Département d'Electricité et du Téléphone.

L'ordonnance No 8 de 1944 "to provide for the preservation of Ancient Monuments and places or areas of historical or other interest' vient remplir un but longtemps désiré. En effet, l'ancienne ordonnance révoquée par celle-ci ne prévoyait que la préservation des monuments historiques, tandis que la nouvelle loi va donner une protection adéquate aux vestiges de la flore et de la faune indigènes de l'île. Cette loi prévoit la création de " National Reserves ", c'est-à-dire de superficies couvertes par des forêts ou autres types de végétation qui seront délimitées et qui ne pourront plus être exploitées par quiconque. Une liste de ces réserves est en préparation ainsi que la nomenclature des monuments historiques à laquelle seront ajoutées les cheminées des anciennes usines de l'île ou même les vestiges de certaines sucreries. Le " Ancient Monuments and National Reserves Advisory Board " qui siège depuis le mois de mai a été ainsi constitué pour 1944 : Président, l'Hon. André Raffray; Secrétaire M. P. O. Wiehe ; Membres, les Hons. P. Raffray, O.B.E., K.C. ; R. Rivet, M.B.E. ; A. Vallet ; Dr. R. E. Vaughan ; et MM. J. A. Carver et R. Lincoln.

Nous extrayons du journal d'une personnalité de l'époque les notes suivantes :

12*th June* 1858 : " Went from Grand'Baie to Mapou passing through several estates. I never saw the canes look so well but there are evident signs of the Borer and in some parts for want of labourer the plantations are not so clean as they ought to be. However the crop will be abundant." Il semblerait que quatre vingt huit ans après, la remarque au sujet de la main-d'œuvre soit encore d'actualité...

COMPTES RENDUS DES CONFÉRENCES ORGANISÉES PAR L'ASSOCIATION DES ANCIENS ÉTUDIANTS DU COLLÈGE D'AGRICULTURE

Réunion du 5 mai 1944.

Présidence de M. A. de Sornay.

Etaient présents : MM. M. Souchon, A. de Sornay, Francis N. Coombes, G. Mazery, R. Rivalland, S. Dupont de R. St. Antoine, O. d'Hotman, R. Lincoln, J.V. Descroizilles, Ph. Pennant, A. Baissac, P. O. Wiehe, G. Park, C. Noël, E. Rochecouste, L. de Chazal, P. Humbert, F. Staub, R. Noël, A. Moutia, F. Nadeau, E. Brown, V. Olivier, P. Samouilhan, R. Pilot, O. Davidsen, A. Delord, A. Harel, T. Dooknah, J. Berchon, G. Rouillard, R. Antoine, P. Courtois, R. Mamet, F. de Robillard, R. Belcourt, L. G. Fayd'Herbe, A. Giraud, S. Félix, C. Kœnig, T. Maigrot, H. Kœnig, P. G. Ducray, Y. G. Toolsy, P. R. Scott, R. Hardy, J. Comty, M. Yardin, H. G. Wiehe, P. Bonieux, B. D. N. Roy, J. de M. Chelin, R. de S. de Pitray, J. Brouard, J. A. C. Cantin, F. Mayer, R. Bouvet, J. Dupont de Rivalz St. Antoine, G. Lionnet, N. d'Avray, P. Guérandel, H. Leclézio, M. Sooltangos, P. R Thélémaque, P. de Gersigny.

Se sont fait excuser : Hon. G. E. Bodkin, C. B. E., MM. S. Staub, N. Craig, G. Orian, F. E. Lionnet, A. Vinson, Capt. A. North Coombes.

LE DIAGNOSTIC FOLIAIRE :

Méthode de contrôle biochimique de l'alimentation minérale des cultures de canne à sucre.

par

N. CRAIG et P. HALAIS
Station de Recherches sur la Canne à Sucre, Réduit.

I. Exposé théorique.

Certaines considérations sur la physiologie végétale et ses rapports avec la chimie agricole serviront d'introduction à cette communication avant d'aborder l'essentiel des résultats expérimentaux obtenus par nous depuis 1936, (1) tant au champs, sur bon nombre de plantations sucrières de l'île, que dans le laboratoire de biochimie de la station du Réduit.

Ce bref exposé paraît indispensable à la compréhension du sujet

pour la simple raison que la doctrine invoquée ici n'est pas encore entrée dans l'enseignement classique, elle ne se trouve pas davantage dans les manuels d'agronomie les plus en usage.

C'est à Henri Lagatu et à Louis Maume (2) de l'École Nationale d'Agriculture de Montpellier que l'on doit d'avoir démontré expérimentalement, au cours de ces vingt dernières années, la doctrine conduisant à ce qu'ils ont appelé : " Le contrôle biochimique des cultures en place " (3). W. Thomas (4, 5) de la Station Agricole de Pennsylvanie s'est fait le véritable promoteur de cette nouvelle méthode aux Etats Unis. H. Lundegardh (6) d'Uppsala, Suède, ainsi qu'une pléiade d'autres chercheurs (7) ont démontré tout le parti que l'on peut en tirer avec les cultures les plus diverses depuis la pomme de terre par exemple jusqu'aux arbres fruitiers.

Les agronomes de la Station Expérimentale de l'Association Hawaïenne des planteurs de canne, Yuen (8), Hance, Clements (9) et Moriguchi, n'ont pas manqué d'en faire le sujet de recherches extrêmement intéressantes et encore en cours d'exécution. Ces derniers n'ont publié jusqu'ici que leurs conclusions préliminaires au sujet de l'alimentation azotée de la canne. D'autre part, Beauchamp (10) Lazo et Bonnazi de la Station cubaine d'Agronomie ont porté leur attention sur l'extrait alcoolique des feuilles comme moyen d'investigation en matière de nutrition minérale de la canne.

Necessité agronomique d'une consultation de la plante.

Lorsqu'à la suite d'une recherche, l'agronome veut conclure, il lui reste toujours des doutes, si la plante n'a pas été consultée en plein champ : de là la supériorité de l'expérimentation culturale (en dépit des difficultés de sa réalisation) sur les techniques indirectes, comme l'analyse du sol par exemple. Or, comme cet interrogatoire de la plante est finalement nécessaire, pourquoi donc ne pas commencer par lui et découvrir par voie d'analyse, quelles sont les répercussions des conditions environnantes (sol, atmosphère et interventions techniques) sur le chimisme interne d'une espèce ou d'une variété cultivée ? En se documentant ainsi auprès de la plante, on part des faits concrets dans le processus d'alimentation, déterminés à la fois par toutes les contingences de la pratique culturale.

Le Mode d'alimentation.

Le mode d'alimentation que réalise une plante cultivée dans un milieu donné se caractérise par l'évolution des concentrations des éléments nutritifs ainsi que par leurs rapports mutuels à l'intérieur de la plante entière, tels qu'ils sont révélés par l'analyse chimique de cette dernière, poursuivie périodiquement tout au cours de son cycle végétatif.

En ce qui concerne les éléments nutritifs majeurs, il est commode d'en interpréter les variations à l'aide de diagrammes spéciaux. Les concentrations qui constituent le facteur quantitatif ou intensité de l'alimen-

tation sont représentées par la somme des teneurs $N + P_2 O_5 + K_2 O$ dans la matière sèche.

Le point de vue qualitatif où nature de l'alimentation est caractérisé par les rapports physiologiques ternaires où $N + P_2O_5 + K_2O = 100$.

La Feuille, organe sensible et accessible.

La détermination du mode d'alimentation par la méthode précitée est fort laborieuse et même irréalisable en pratique, tout au moins pour les plantes à grand développement, comme la canne par exemple, en raison des difficultés d'échantillonnage et de manipulation de masses végétales aussi importantes.

C'est pour cette raison que Lagatu et Maume ont pensé à substituer à la plante entière, un organe sensible et accessible. Ils se sont adressés, en ce qui concerne les végétaux encombrants, à une feuille prise en place, convenablement choisie pour instituer par le " diagnostic foliaire " un Test de la nutrition minérale, c'est-à-dire : " un fragment minime de la réalité par lequel on prétend, après information expérimentale, pouvoir estimer la réalité toute entière ".

Période critique de la végétation.

Le nombre des prélèvements périodiques peut être réduit, sans grand dommage, si l'on se confine à l'essentiel : un ou deux prélèvements au moment même où la plante atteint le point culminant de sa végétation et où elle dépend essentiellement des conditions du milieu.

Hiérarchie entre éléments nutritifs.

Au lieu d'étudier simultanément tous les éléments dits nutritifs, on commence d'abord par les éléments majeurs que l'expérience a démontré être les plus importants soit : l'azote, l'acide phosphorique, et la potasse, c'est-à-dire ceux apportés en pratique par les engrais du commerce.

Cela n'empêchera pas de compléter ces études par celles ayant trait à la teneur des feuilles en chaux, en magnésie etc. et d'arriver finalement, si la chose est nécessaire, à ces oligo-éléments dont la physiologie végétale fait aujourd'hui grand cas.

Intérêt agricole de l'Etude du Mode d'alimentation.

Lagatu et Maume (11) vont aussi nous répondre :

(a) Un ensemble déterminé de concentrations et de rapports entre éléments nutritifs, à l'intérieur de la plante, révélé par l'analyse chimique périodique, correspond à un mode d'alimentation déterminé et à un mode corrélatif de développement physiologique et morphologique.

(b) A un mode choisi et réussi d'exploitation d'une plante cultivée

dans une région agricole définie, correspond des concentrations et des rapports d'éléments nutritifs particuliers qui se caractérisent alors comme *un optimum nutritif*. Beaucoup de facteurs peuvent y faire obstacle, d'où insuccès des cultures dont l'équilibre nutritif est plus ou moins éloigné de l'optimum, soit par carence relative soit par excès relatif d'un ou de plusieurs éléments nutritifs.

(c) Lorsque dans un sol qui ne nourrit pas la plante cultivée selon l'équilibre nutritif optimum souhaité, l'intervention d'un engrais a eu pour résultat d'approcher ou d'atteindre cet équilibre, le rendement est accru dans le sens voulu de l'exploitation de cette plante.

Progrès de la chimie analytique.

La mise en œuvre des progrès réalisés dans le domaine de la chimie analytique, en particulier des procédés récents par microdosage, (12, 13, 14) propres au travail en grande série, est indispensable à la réalisation du contrôle biochimique des cultures. Plus rapides et beaucoup moins coûteux que les procédés classiques de la chimie agricole, ils gardent cependant une exactitude largement suffisante.

Rôle des Laboratoires agricoles.

On est donc amené à conclure, de ce qui précède, que la tâche à la fois urgente et efficace des laboratoires de chimie agricole peut se résumer ainsi (11) :

(a) Etablir les concentrations et les rapports des divers éléments nutritifs qui constituent l'optimum nutritif d'une culture régionale.

(b) Mesurer les concentrations et les rapports qui se réalisent dans les champs.

(c) Donner des indications quant aux meilleures formules d'engrais susceptibles d'amener ces cultures à l'optimum nutritif avec le minimum de frais.

Réalisations à la Station de Recherches.

Nous avons déjà réalisé l'essentiel de ce programme à la Station du Réduit. Il reste cependant à trouver, d'accord avec les intérêts, comment faire fonctionner le contrôle proprement dit sur une base suffisamment grande, pour que toutes les cultures de canne de l'île puissent en bénéficier.

L'industrie sucrière sera alors dotée pour la première fois d'un système réellement efficace de contrôle des fumures, qui permettra d'éviter les erreurs économiques et techniques du passé, voir les apports en excès, improductifs, ou les apports insuffisants, entraves aux meilleures rendements. En un mot, aider par une fumure rationnelle à faire un meilleur usage des propriétés inhérentes au sol, des conditions atmosphériques qui prévalent, du potentiel des variétés de cannes améliorées et des interventions techniques onéreuses.

II. Pratique du Diagnostic foliaire de la canne.

Nous donnons ci-après des instructions précises quant aux règles à suivre pour le diagnostic foliaire de la canne, telles qu'elles ont été établies par la Station de Recherches pour les conditions locales.

Il va de soi que la valeur numérique de l'optimum nutritif souhaité, qui constitue la clé d'interprétation du contrôle, n'est valable que dans la mesure où ces règles seront respectées. Il est du reste très facile d'y adhérer, le seul point délicat consistant dans l'appréciation des conditions atmosphériques ayant prévalu avant que les feuilles ne soient échantillonnées, car l'absorption minérale est conditionnée par celle de l'eau.

Certes, l'interprétation sera complétée par la considération d'autres éléments ou même modifiée au fur et à mesure des progrès réalisés et de l'expérience acquise au cours de la poursuite du contrôle.

Echantillonnage au champ.

Catégorie de canne : Repousses.

Age de la canne : de 5 à 6 mois.

Mois de l'année : de janvier à avril.

Variété : celles déjà répandues et étudiées.

Stade en croissance : En pleine végétation.

Conditions atmosphériques : Exclusion de toute sécheresse récente ou de la période suivant un cyclone.

Rang de la feuille : La troisième feuille en partant du sommet, celle partiellement déroulée comptant comme la première.

Partie de la feuille : Le limbe entier.

Choix des tiges portant la feuille : Tiges à tout venant.

Nombre de feuilles à prélever : Au moins une cinquantaine judicieusement réparties sur tout le champ.

Nombre de prélèvements : Préférable d'en faire deux au cours de la période janvier à avril, l'un à cinq mois et l'autre à six, si les conditions atmosphériques le permettent.

Préparation au Laboratoire.

Sectionner tout l'échantillon en morceaux d'environ un centimètre, bien mélanger, sous-échantillonner et dessécher à l'étuve réglée à 80 °C.

Réduire en poudre impalpable dans un broyeur mécanique. L'échantillon ainsi desséché et mis à l'abri de l'humidité se conserve parfaitement bien.

Analyse Chimique.

Toute méthode bien contrôlée peut être employée. Celles généralement suivies à la station pour :

L'Azote

Procédé Kjeldahl employant le catalyseur de Beet et Furzey au selenium et mercure. Distillation dans l'appareil Parnas et Wagner, l'ammoniac étant recueilli dans de l'acide borique dilué.

L'Acide phosphorique

Minéralisation nitro-sulfo perchlorique selon Maume, Dulac et Bouat. Précipitation par le réactif nitromolybdique sulfaté de Lorenz. Titrage alcalimétrique en présence de formol selon Scheffer.

La Potasse

Minéralisation nitro-sulfo perchlorique. Elimination de l'ammoniac par l'eau régale. Précipitation par le réactif nitro cobaltique de Garola et Braun. Lavage du précipité par centrifugation à l'aide d'acide acétique dilué. Titrage du précipité par oxydation au permanganate selon Milne.

Des procédés plus rapides devront être employés lorsqu'il s'agira du contrôle proprement dit. Par exemple, une seule minéralisation selon J. Cartiaux (15) employant l'eau oxygénée concentrée pure en milieu sulfurique permet le dosage simultané de N, P, etc sur une faible prise d'essai. L'azote peut alors être déterminé par nesslérisation, l'acide phosphorique par céruleo-molybdimétrie, et la potasse par néphélométrie.

Tous les résultats d'analyse sont exprimés en azote N, en acide phosphorique P_2O_5 et en potasse K_2O, pour cent de la matière sèche de la feuille.

III. Interprétation.

Aire de l'optimum nutritif NPK.

Variété	*Azote* N	*Acide Phosphorique* P_2O_5	*Potasse* K_2O.
M 134/32 et M 112/34	1.40 — 1.50	0.44 — 0.50	2.35 — 2.65
BH 10/12 et Big Tanna	1.35 — 1.45	0.36 — 0.40	2 20 — 2.50
M 171/30	1.22 — 1.30	0.34 — 0.38	2.00 — 2.30

L'optimum nutritif pour les variétés anciennes courantes, BH 10/12 et Big Tanna a été établi d'après des comparaisons directes faites à la suite d'apports d'engrais dans des essais culturaux. Par contre, les valeurs de l'optimum pour les variétés nouvelles furent calculées en tenant compte des différences constantes de composition minérale des feuilles enregistrées au cours d'essais comparatifs avec les variétés anciennes précitées.

En ce qui concerne l'azote, l'optimum régional paraît se rapprocher de la limite inférieure dans les localités sous-humides de l'île pour atteindre la limite supérieure dans les localités super-humides.

Apports d'Engrais.

Pour en venir finalement aux quantités d'engrais à employer de manière à corriger l'équilibre nutritif selon les indications du diagnostic, il y a lieu, pour le moment, de procéder par approximations successives en prenant comme base les doses appliquées couramment, soit en les réduisant ou bien en les forçant selon nécessité.

Ces changements dans les formules d'engrais ne seront entrepris qu'au cours d'une prochaine saison culturale. Seule, la poursuite d'un nouveau diagnostic permettra de juger de la réussite plus ou moins complète du changement alimentaire intervenu et de diriger le sens des retouches éventuelles à entreprendre. Il s'agit donc d'un contrôle continu et permanent.

IV. Justification Expérimentale.

La dernière partie de cette communication se rapporte aux preuves étayant la valeur numérique de l'optimum nutritif souhaité. Cette clé d'interprétation est basée sur des recherches dont a continuité et l'ampleur ne sont réalisables qu'en utilisant les ressources que seule possède une station de recherche spécialisée. Ainsi, plus d'une soixantaine d'essais culturaux avec les engrais, entrepris dans les conditions de la pratique au cours de ces dernières années et réparties sur tout le territoire sucrier de l'île et comprenant des centaines de diagnostics foliaires s'y rattachant, sont invoqués dans les représentations graphiques et les tableaux résumés, plus loin.

Nous nous sommes arrêtés à ce procédé visuel qui est beaucoup plus expéditif et compréhensif que la comparaison de tableaux encombrés de chiffres. Il a été jugé utile, toutefois, de dresser des tableaux résumés.

Explication des Diagrammes.

Quatre diagrammes différents démontrent séparément la relation qui existe entre les données du diagnostic foliaire et les augmentations de rendement en canne obtenues à la suite d'apports d'engrais (1) azotés (2) phosphatés (3) potassiques et (4) complets (NPK).

Le but d'une fumure idéale consiste à atteindre l'optimum nutritif souhaité représenté pour chaque élément par l'intervalle compris entre deux lignes horizontales parallèles. Cet optimum se rapporte à la BH 10/12 et à la Big Tanna, variétés les plus représentées dans les essais.

Tout ce qui a trait à l'azote est inscrit en vert, aux phosphates en rouge et à la potasse en bleu. L'échelle employée pour les teneurs des feuilles en acide phosphorique est double de celle pour l'azote et la potasse.

Le point de départ — ou teneur initiale — de la feuille témoin c'est-à-dire, celle qui n'a pas reçu l'engrais choisi, est figuré par un cercle, tandis que le point d'arrivée — ou teneur réalisée — de la feuille fumée est représentée par une flèche.

D'autre part, les augmentations de tonnage de canne provoquées par l'engrais sont figurées par des colonnes verticales.

Pour chaque diagramme, les essais différents ont été rangés en ordre croissant de teneur initiale de la feuille témoin en l'élément nutritif considéré. On pourra retrouver dans l'appendice I la variété, cultivée ainsi que l'année et le district où les essais ont été entrepris.

Il ressort de l'étude des diagrammes que le redressement alimentaire est d'autant plus nécessaire que les points de départ sont plus éloignés de l'optimum nutritif. Les diagrammes démontrent en même temps que la fumure est d'autant plus efficace, comme l'atteste les augmentations de rendement en canne, que les points d'arrivée sont plus rapprochés de l'optimum souhaité. Et c'est précisément la thèse que nous voulions démontrer.

Il aurait mieux valu tabler sur les augmentations en sucre commercial, but ultime de l'exploitation sucrière, plutôt que sur celles du tonnage de canne pour juger de l'opportunité et de l'efficacité d'une fumure ; malheureusement, la richesse saccharine des cannes ne peut être obtenue dans tous les cas avec égale précision. Nos conclusions sur ce point sont cependant très nettes comme l'indiquent les moyennes fournies aux tableaux résumés.

Les engrais azotés, appliqués tardivement et à dose exagérée — c'est-à-dire dépassant l'optimum nutritif pour l'azote — n'augmentent guère le tonnage de canne, ils réduisent cependant d'une manière significative le pourcentage de sucre récupérable. Quand aux phosphates, ils n'exercent que peu d'influence sur la richesse de la canne. Par contre, les engrais potassiques ne provoquent l'amélioration de la richesse saccharine qui leur est généralement attribuée que dans le mesure où ils ont augmenté en même temps le tonnage de canne.

Tableaux résumés.

Les quatre tableaux ci-après donnent les résultats moyens pour les essais d'engrais et les diagnostics foliaires correspondants, groupés selon l'importance des augmentations de tonnage de canne enregistrées. Les différences moyennes de richesse saccharine obtenues y sont aussi consignées. Les engrais azotés ont été apportés en moyenne à raison de 30 Kgs. d'azote à l'arpent, et les engrais phosphatés et potassiques à raison de 40 Kgs. d'acide phosphorique ou de potasse à l'arpent.

Tableau I.

Essais avec Engrais Azotés

Augmentations de tonnage de canne	Nombre d'essais différents	Diagnostics Foliaires						Effet de l'Engrais sur :	
		Teneurs initiales (sans azote)			Teneurs réalisés (avec azote)			Le tonnage de canne à l'arpent	La richesse saccharine %
		N	P_2O_5	K_2O	N	P_2O_5	K_2O		
— 2 à + 2	1	1.56	0.46	2.39	1.54	0.44	2.45	+ 0.1	— 0.3
+ 2 à + 4	4	1.15	0.42	2.20	1.31	0.39	2.27	+ 2.6	— 0.4
+ 8 à + 16	1	0 97	0.44	1.92	1.34	0.41	2.00	+ 13.0	— 0.9

Tableau II.

Essais avec Engrais Phosphatés

Augmentations de tonnage de canne	Nombre d'essais différents	Diagnostics foliaires						Effet de l'Engrais sur :	
		Teneurs initiales (sans phosphate)			Teneurs réalisées (avec phosphate)			Le tonnage de canne à l'arpent	La richesse saccharine %
		N	P_2O_5	K_2O	N	P_2O_5	K_2O		
— 2 à + 2	12	1.39	0.36	2.12	1.33	0.40	2.12	+0.2	0.0
+ 2 à + 4	5	1.27	0.34	1.89	1.28	0.40	1.81	+2.7	—
+ 4 à + 8	2	1.62	0.29	2.01	1.55	0.38	1.99	+5.1	— 0.1
+ 8 à + 16	4	1.34	0.23	1.61	1.33	0.30	1.49	+10.2	0.0

Tableau III.

Essais avec Engrais Potassiques

Augmentations de tonnage de canne	Nombre d'essais différents	Diagnostics foliaires						Effet de l'Engrais sur :	
		Teneurs initiales (sans potasse)			Teneurs réalisées (avec potasse)			Le tonnage de canne à l'arpent	La richesse saccharine %
		N	P_2O_5	K_2O	N	P_2O_5	K_2O		
— 2 à + 2	8	1.39	0.36	2 11	1.41	0.37	2.26	+ 0.6	0.0
— 2 à + 4	5	1.38	0.37	1.87	1.37	0.37	2.15	+ 2.5	+ 0.4
+ 4 à + 8	7	1.44	0.37	1.20	1.43	0.39	1.93	+ 6.5	+ 0.9
+ 8 à + 16	2	1.65	0.40	0.86	1.55	0.40	2.03	+ 9.9	+ 0.6

Tableau IV.

Essais avec Engrais Complet N P K.

Augmentations de tonnage de canne	Nombre d'essais différents	Diagnostics foliaires						Effet de l'engrais sur :	
		Teneurs initiales (sans engrais)			Teneurs réalisées (avec engrais complets)			Le tonnage de canne à l'arpent	La richesse saccharine o/o
		N	P_2O_5	K_2O	N	P_2O_5	K_2O		
— 2 à + 2	4	1.43	0.37	2.13	1.46	0.37	2.23	— 0.3	—
+ 2 à + 4	1	1.18	0.30	1.66	1.28	0.34	2.14	+ 3.7	—
+ 8 à + 16	6	1.22	0.31	1.07	1.44	0.32	1.56	+ 12.6	—

V. Conclusion.

Le contrôle biochimique des cultures de cannes s'impose dans le but de remédier aux déséquilibres alimentaires par une fumure réellement appropriée à chaque cas particulier constituant la grande diversité des conditions rencontrées en pratique. On ne peut y parvenir par aucune autre voie aussi directe, sûre et économique que celle du diagnostic foliaire; on n'en connait pas non plus de mieux adaptée à la monoculture d'une

plante vivace à grand développement comme la canne. Seul, le diagnostic foliaire peut prétendre avoir subi une confrontation expérimentale adéquate à Maurice.

Le coût d'un tel contrôle permanent des cultures de canne paraît insignifiant quand on le compare aux avantages d'une rationalisation du problème des engrais dans une industrie sucrière où ces derniers occupent une place si importante.

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APPENDICE I.

Essais avec Engrais Azotés.

Numéros d'ordre des essais	*Variété*	*Année*	*District*
1	M 134/32	1942	Pamplemousses
2	BH 10/12	1941	Pamplemousses
3	M 134/32	1942	Grand Port
4	BH 10/12	1938	Savane
5	BH 10/12	1940	Pamplemousses
6	M 134/32	1942	Savane

Essais avec Engrais phosphatés.

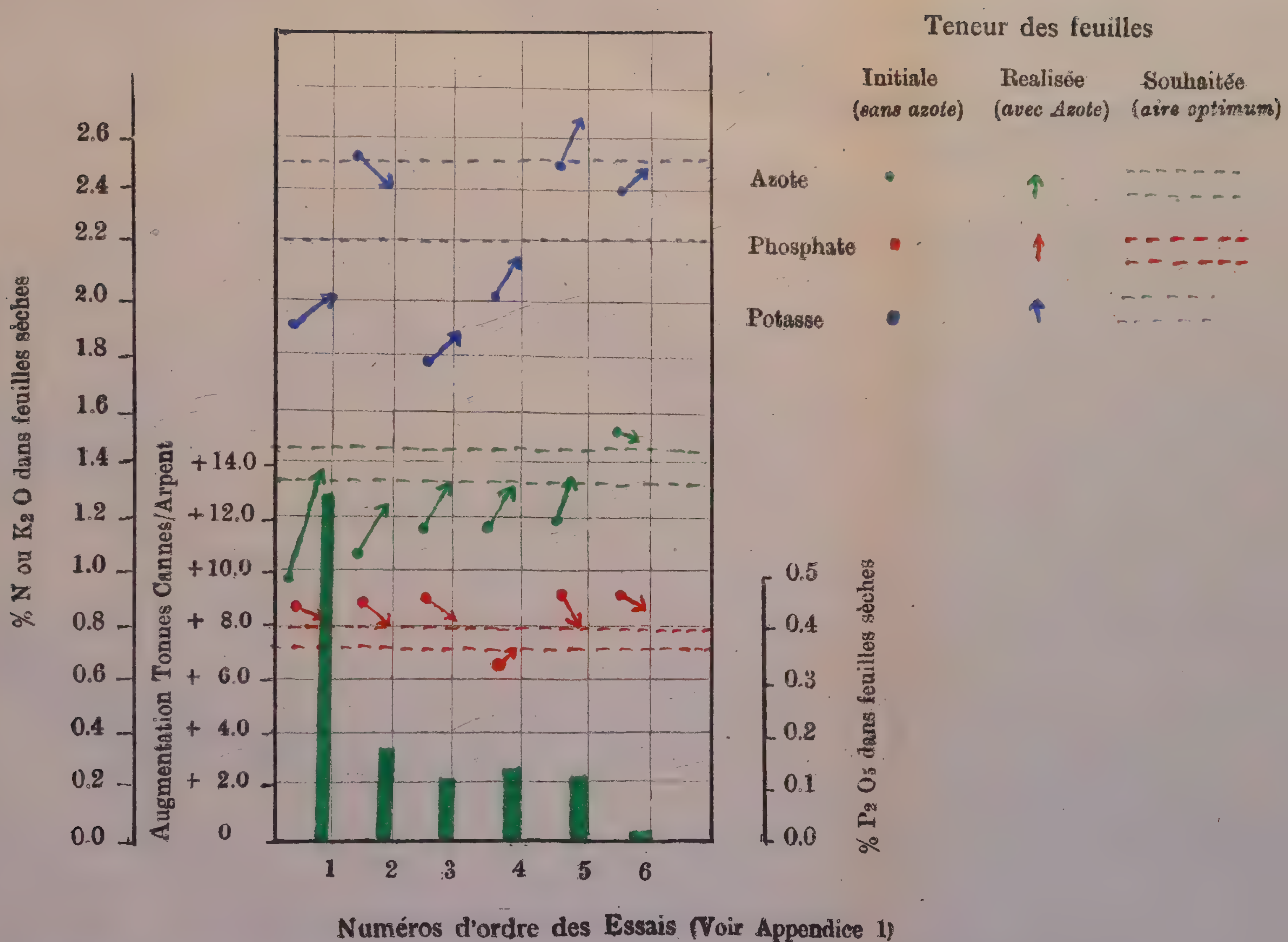
	Variété	*Année*	*District*
7	En mélange	1939	Flacq
8	En mélange	1939	Flacq
9	En mélange	1940	Flacq
10	En mélange	1941	Grand Port
11	BH 10/12	1938	Moka
12	BH 10/12	1939	Moka
13	M 134/32	1941	Moka
14	En mélange	1940	Flacq
15	Big Tanna	1940	Grand Port
16	BH 10/12	1938	Savane
17	Big Tanna	1939	Grand Port
18	BH 10/12	1941	Grand Port
19	Big Tanna	1941	Grand Port
20	Big Tanna	1940	Pamplemousses
21	BH 10/12	1940	Moka
22	BH 10/12	1940	Grand Port
23	BH 10/12	1939	Grand Port
24	BH 10/12	1939	Moka
25	En mélange	1940	Plaines Wilhems
26	BH 10/12	1940	Savane
27	En mélange	1941	Plaines Wilhems
28	BH 10/12	1941	Savane
29	BH 10/12	1939	Savane

Essais avec Engrais potassiques.

Numéros d'ordre des essais	*Variété*	*Année*	*District*
30	BH 10/12	1939	Grand Port
31	Big Tanna	1939	Grand Port
32	BH 10/12	1940	Grand Port
33	BH 10/12	1939	Moka
34	Big Tanna	1940	Grand Port
35	BH 10/12	1938	Moka
36	Big Tanna	1941	Grand Port
37	BH 10/12	1941	Grand Port
38	M 134/32	1941	Moka
39	Big Tnnna	1939	Savane
40	Big Tanna	1940	Pamplemousses
41	BH 10/12	1941	Grand Port
42	BH 10/12	1938	Savane
43	Big Tanna	1940	Savane
44	M 72/31	1941	Riv. du Rempart
45	Big Tanna	1941	Riv. du Rempart
46	BH 10/12	1940	Grand Port
47	BH 10/12	1939	Grand Port
48	BH 10/12	1940	Moka
49	BH 10/12	1939	Moka
50	M 27/16	1940	Flacq
51	M 27/16	1939	Flacq

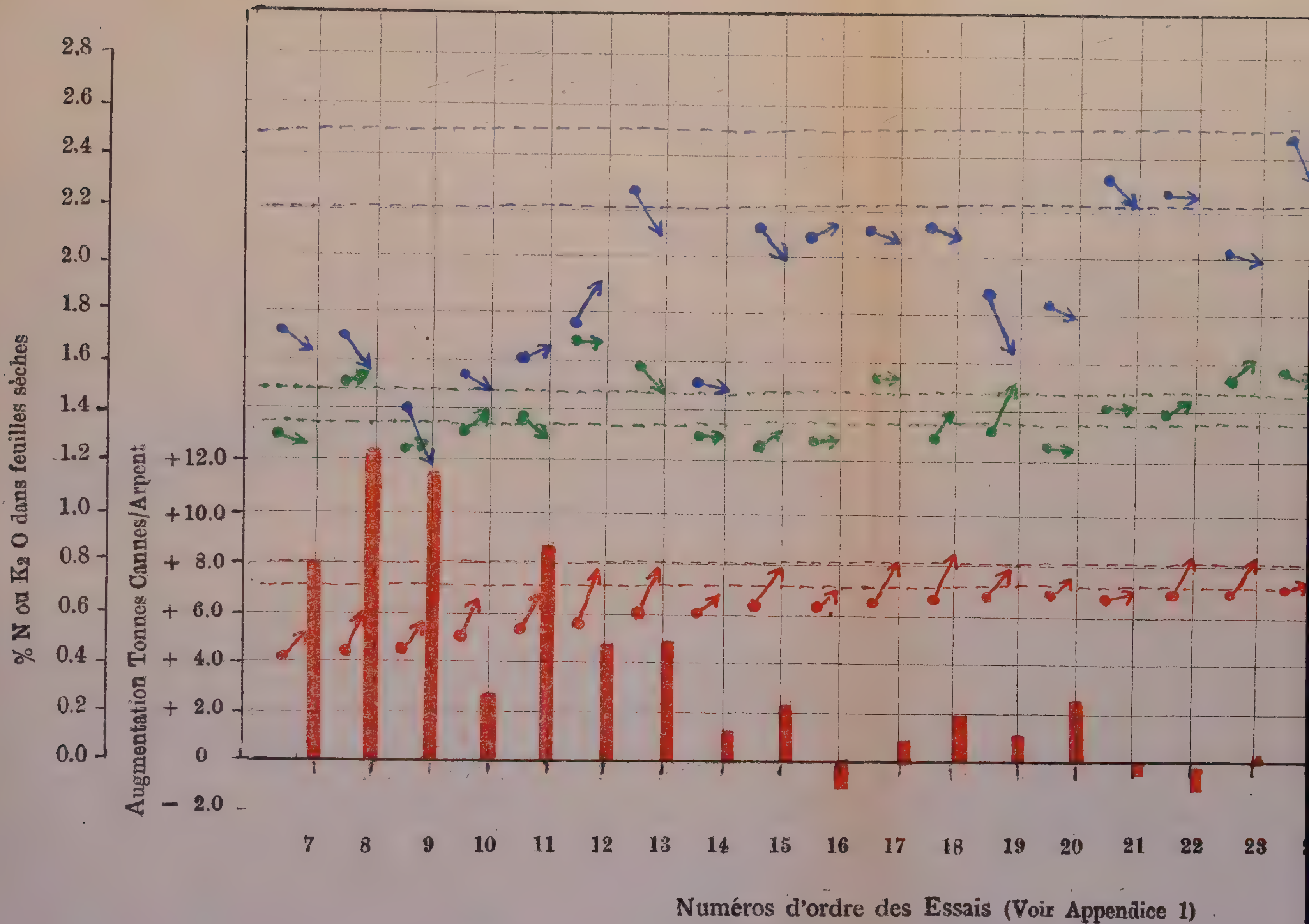
Essais avec Engrais complets (N P K).

	Variété	*Année*	*District*
52	M 171/30	1940	Moka
53	M 171/30	1941	Moka
54	M 134/32	1940	Moka
55	M 27/16	1937	Moka
56	M 134/32	1941	Moka
57	M 27/16	1938	Moka
58	BH 10/12	1938	Savane
59	Big Tanna	1939	Savane
60	Big Tanna	1940	Savane
61	Big Tanna	1939	Flacq
62	Big Tanna	1940	Flacq



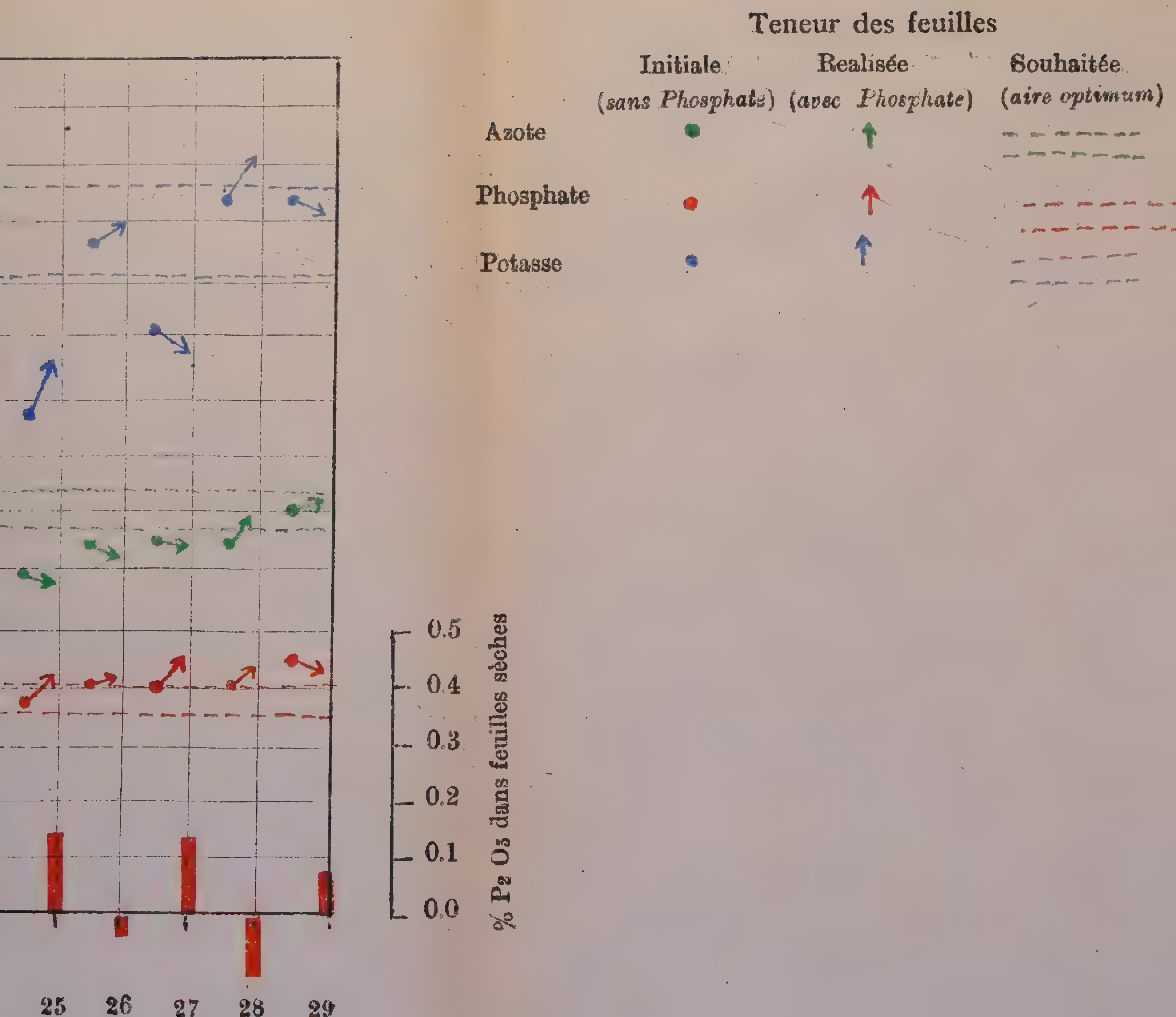
Diag. 1. *Essais culturaux avec engrais Azotés* montrant la relation entre le diagnostic foliaire et l'augmentation de rendements en Cannes.

Les augmentations de rendements réalisées à la suite d'apport d'azote sont indiquées par les bâtonnets verts. Les teneurs des feuilles en Azote, Acide phosphorique et Potasse sont représentées d'après les indications de la légende à droite du diagramme.



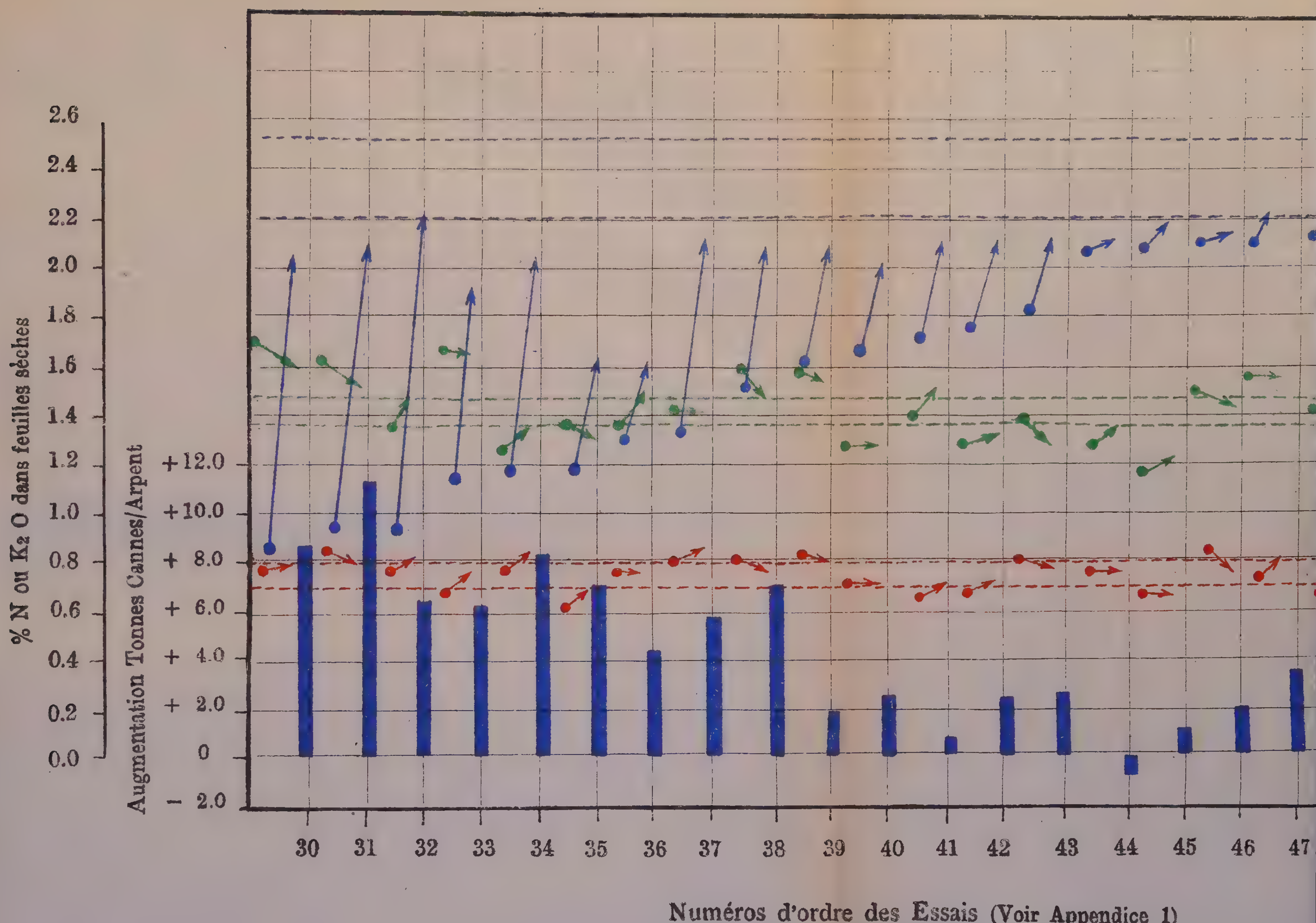
Diag. 2. *Essais culturaux avec engrais Phosphatés* montrant la relation entre le diagnostic foliaire et
en Cannes.

Les augmentations de rendements réalisées à la suite d'apport de Phosphate sont indiquées
teneurs des feuilles en Azote, Acide phosphorique et Potasse sont représentées d'après la

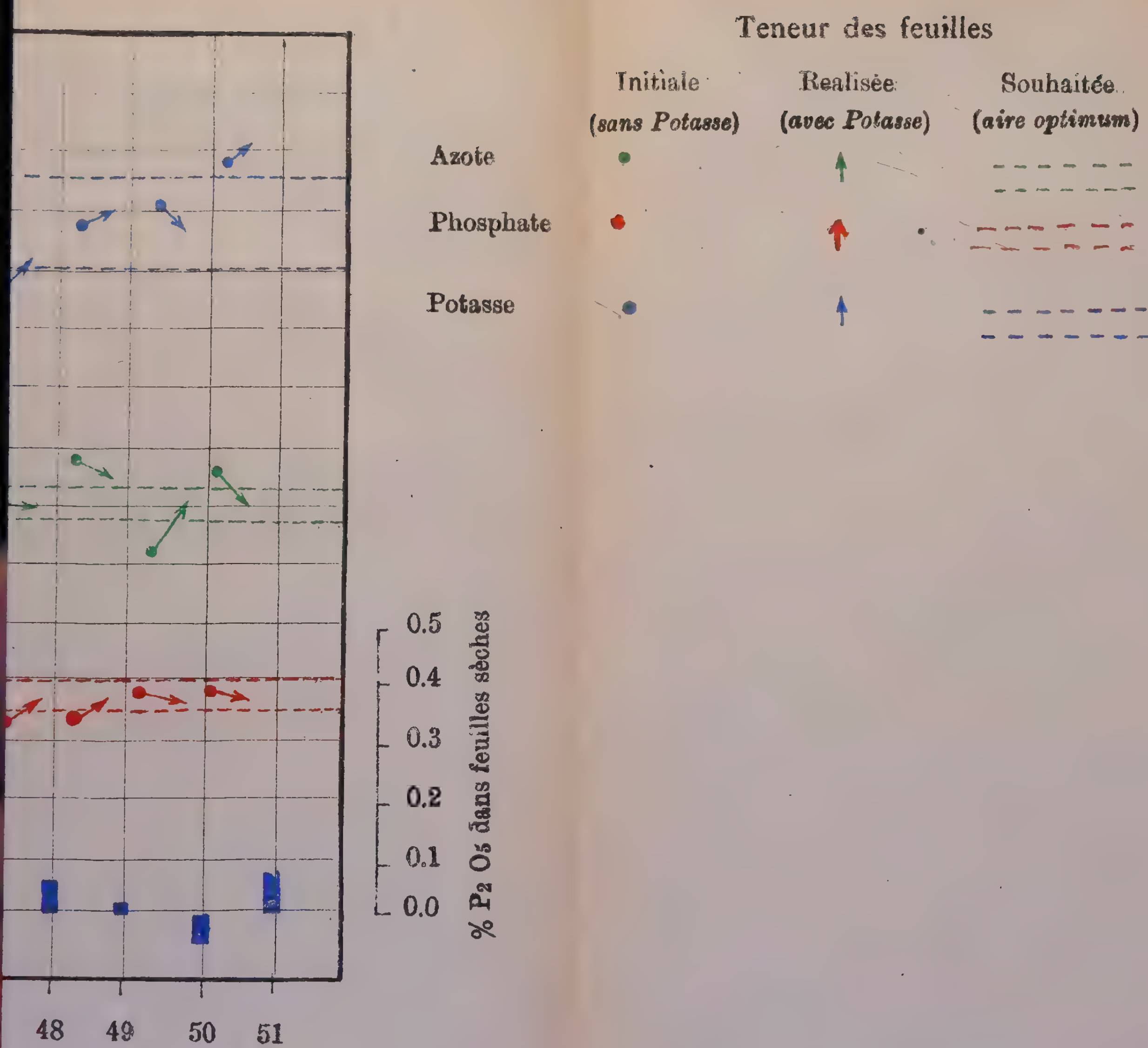


ugmentation de rendements

ar les bâtonnets rouges. Les
gende à droite du diagramme.

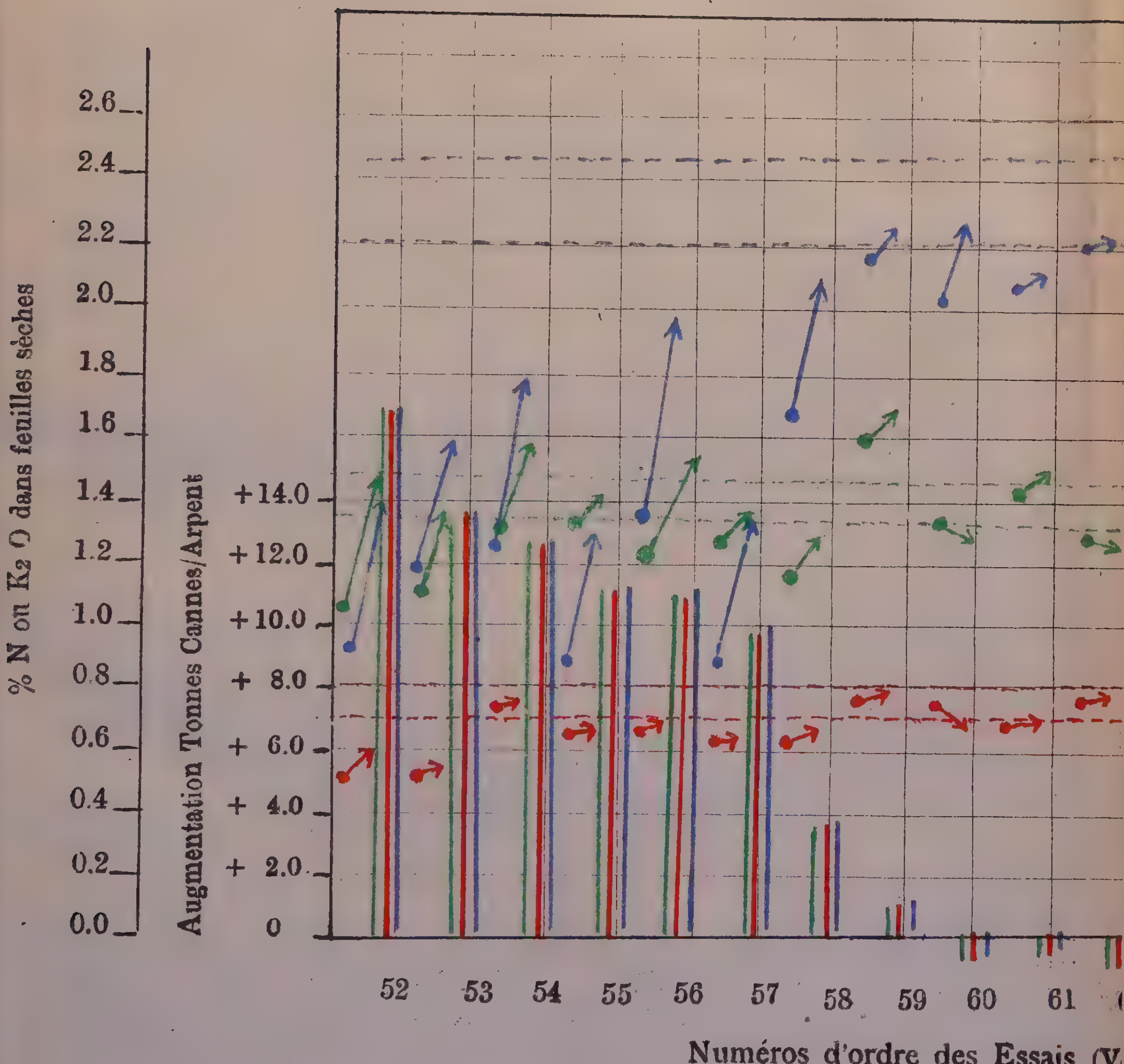


Diag. 3. *Essais culturaux avec engrais Potassiques* montrant la relation entre le diagnostic foliaire et l'augm
en Cannes.
Les augmentations de rendements réalisées à la suite d'apport de Potasse sont indiquées par les bât
des feuilles en Azote, Acide phosphorique et Potasse sont représentées d'apres les indications
diagramme.

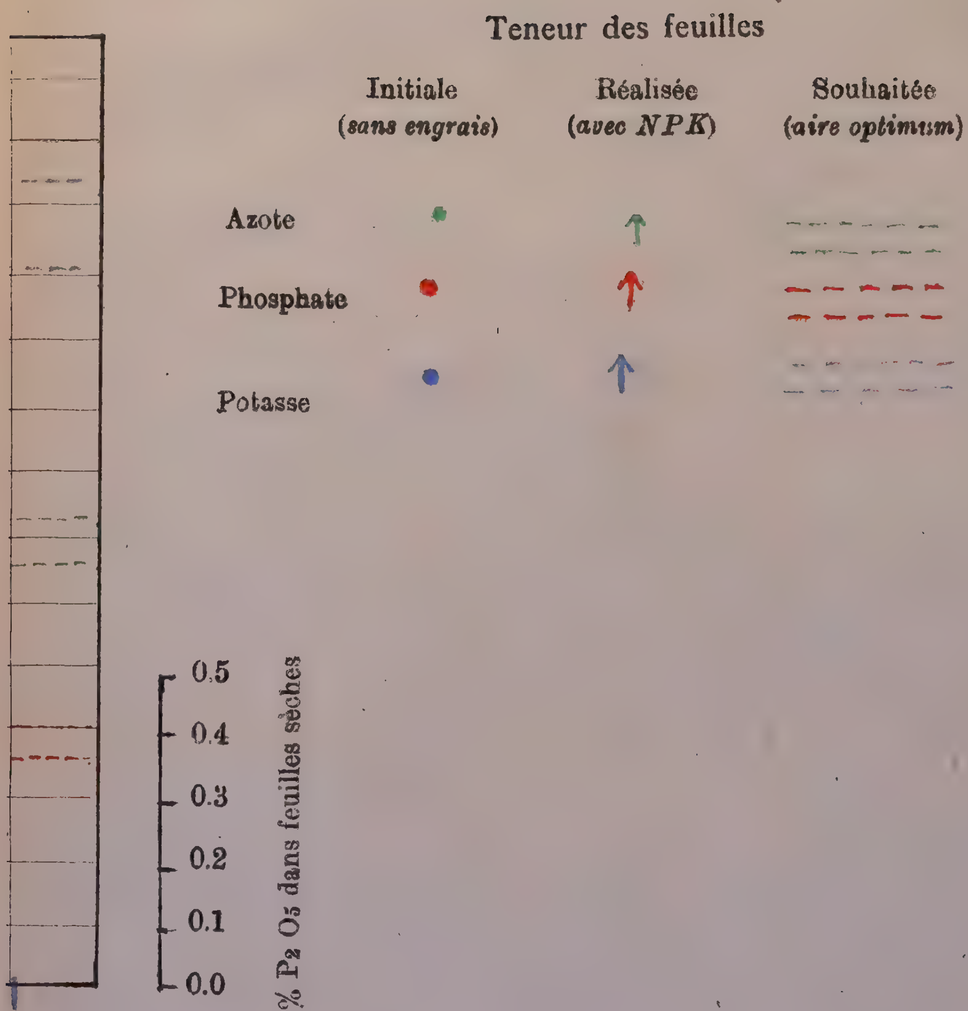


nentation de rendements

onnets bleus. Les teneurs
de la légende à droite du



Diag. 4. *Essais culturaux avec engrais complets (NPK)* montrant l
et l'augmentation de rendements en Cannes
Les augmentations de rendements réalisées à la suite
sont indiquées par les bâtonnets tricolores. Les teneu
phorique et Potasse sont représentees d'apres les i
diagramme.



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oir Appendice 1)

a relation entre le diagnostic foliaire

d'apport d'engrais complets (NPK)
ırs des feuilles en Azote, Acide phos-
ndications de la légende à droite du

CONTROL OF MALARIA IN MAURITIUS

C. R. HARRISON

In 1863 the first laws to control irrigation were passed. I do not know whether this is of any significance but we do know that faulty irrigation is a prolific source of mosquito breeding and consequently malarial infection.

Two years later, in 1865 and 1866, malaria broke out in the Colony. It is to be assumed that mosquitoes were landed on the island shortly before that date. Ever since the island has been inhabitated there must have been present some persons with malaria in their blood but it did not spread owing to the absence of the right sort of mosquito.

In those days nobody knew how malaria was caused and the popular opinion was that it was caused by "bad air" rising from the swamps. Hence the name "Malaria".

In 1877 the Senior Medical Officer of Mauritius wrote :

> "It (malaria) closely followed upon and was probably introduced through the fever-germs being conveyed in the rain clouds coming in part from Madagascar during a heavy north west gale, which occurred in February 1865".

You may laugh but it was the best medical opinion of the day and those to follow as in 70 or 80 years time may well laugh at what I am telling you now. It is hoped that science will eventually evolve some simple and cheap method of Biological control. In the meantime we must do the best we can with the knowledge which is at our disposal.

The first step towards control was made by a French doctor, Laveran by name, in North Africa in 1880. He discovered the parasite of malaria in man.

The ancient Greeks in their writings, and in ancient Buddist writings found in Ceylon, as long as 2,000 years ago suggested that mosquitoes carried malaria. In 2,000 years somebody was bound to guess right.

Sir Patrick Manson, a very great man, who had spent part of his life in China, suggested to Major Ronald Ross of the Indian Medical Service that he might explore the mosquito theory.

In spite of many difficulties and active obstruction by the India Authorities, who actually moved him to a place where he could not get mosquitoes, in 1898 Ross proved the life cycle of the malaria parasite with bird malaria.

An Italian named Grassi, following Ross's technic, proved the cycle in man shortly before Ross was able to do so, owing to the difficulties which were put in his way.

Ross, knowing the greatness of his discovery, resigned his Commission and returned to England expecting to lead the world in the war against mosquitoes. His expectations were not realised and he soon found himself

a disappointed and very poor man on his Major's pension with little being done with his great discovery.

The first practical application of his theories was, peculiarly enough, not against malaria but against Yellow Fever.

An American army doctor, named Gorgas, was put in charge of the control of yellow fever in Cuba where he had great success.

On the strength of this, and because of the strategic necessity, the U.S.A. decided to build the Panama Canal and Gorgas was put in charge.

Twice before, attempts were made by the French to build this canal with disastrous results. Very few who made the attempt returned to their native country.

However the Americans succeeded but the world was not impressed. They said that it was too expensive for ordinary every day application and that it was done under martial law. Every body had to be inside their mosquito proofed houses before dusk. I can well imagine anyone trying to lock up the inhabitants of this island every afternoon !

At the same time at a military cantonment, called Mian Mian in India, an effort was made to put into practice Ross's theories. The results, due to lack of understanding, were so disastrous that for 30 years no further efforts were made to control mosquitoes in India.

In 1901 the Government of Malaya were trying to develop a new port, on the west coast of Malaya, called Port Swettenham but the health was very bad and 582 persons died out of 3,500 in that year.

Shipping Companies refused to send their ships to load because the whole crew would be down with malaria before they could reach Colombo. They often had to signal for help to bring the ship into port.

The Governor decided that the development of this port was impossible and wired to have the work stopped.

The Government Medical Officer of the district, in which was Port Swettenham, was Dr. Malcolm Watson. We were very fortunate in having so brilliant a man in the Government service and on the spot. Dr. Watson could not stand the cold so he had decided to pass his career in a really warm spot.

He, on hearing of the Governor's decision, wired to ask if he might have a few thousand dollars, to see if he could not make Port Swettenham healthy by mosquito control. His request was granted and he had great success. In 1902, with an ever increasing population, he dropped the deaths to 144. The port has ever since been a healthy resort.

In this case the vector, i e. carrier of malaria, was *Anopheles sundaicus* (formerly *Ludlowi*) a brackish water breeder. Watson simply bunded out the salt water and let the fresh water out by means of tide gates, so that the waters did not mix and the vector vanished.

This was the first time in history that the practical and economic control of mosquitoes had succeeded. Encouraged by this success, Watson turned his attention to the coastal plain of Malaya, which the early rub-

ber planters had mistakenly selected as the most suitable soil for growing rubber. This land is naturally a huge swamp a few feet above high tide, in which the principal vector was *Anopheles umbrosus.*

Watson found that by removing the camps half a mile from the buildings, the inhabitants were entirely malaria free.

Watson then spread his ideas to the foot hills but met with no success. In fact the health was perfectly appalling. Death rates of [illegible]00 per 1000 were not uncommon on many Estates and mines. One went to work when one could walk, otherwise to bed with aspirine and quinine This was true of staff and labour force. Eventually it was found that the vector was *Anopheles maculatus*, a sunlit stream breeder. So that the more we opened up and drained the valleys the better this mosquito liked the conditions. In 1913 he discovered how to use oil and the technic. He found (too late for the purpose) that if the shade had not been removed this mosquito would not breed in the valleys.

This is where I come into the picture and I am afraid I will be talking rather a lot about myself. This is because I can speak with certainty of what I know. I want you to understand that there were and there are hundreds of other men in Asia, Africa, America and elsewhere who have done likewise or better.

I was a planter and it was my duty to control malaria, and otherwise care for the health of the people under my charge, just as much as it was my duty to supervise the factory, field or office.

In 1910 I became Manager of Midlands Estate, one of the Port most unhealthy Estates and a few miles from Swettenham. Prior to my taking over, no proper records of death rates was kept. The figures were so appalling that the Manager dare not return the true figures and the majority of the dead where shown as deserters. From 1911 onwards I kept accurate records.

Here are some of the records :

Very malarial in 1911 — Subsoil draining and oiling begun in 1913.

		Results of anti-malarial work		
		1911	1923	1932
Acreage cultivated		1,632	2,650	6,801
Average Labour Force	Indians ...	870	450	957
	Chinese ...	Large Numbers	Nil	Nil
Dependents		Practically nil owing to deaths	220	575
F.O.B. per lb.		$ 1.09	.64 cts	7.53 cts
Deaths per 1,000		232	3	1.1

Staff 1911. 7 unhealthy Europeans, constantly sick and feeling that they could never marry.

Staff 1923. 4 healthy Europeans, 3 married, 1 engaged.
3 healthy children. No one sick.

In 1929 Watson, now Sir Malcom Watson and of the Ross Institute, gave me four days to go out to the new copper belt in Northern Rhodesia, near the Congo border, to instruct in the control of malaria. I had retired from planting in 1926 and found the offer attractive but was certainly frightened at suddenly becoming a malaria " expert ".

However, Sir Malcolm assured me that Africa was 30 years behind Malaya in the control of malaria and that all I had to do was to teach the miners the routine practiced on the Estates of Malaya.

Here I may say that the control of malaria on Estates and mines in Malaya was a routine practice which every responsible employee was expected to understand and carry out. Woe betide any employee who failed in this work. I had slightly more experience than the average planter because the estate which I managed happened to be conveniently situated and sufficiently unhealthy for many researches and experiments to be carried out on it. It was amongst other things the first estate on which oil was used. I stayed in Northern Rhodesia for four months, instructing and laying out the schemes on three mines.

Here are some recent figures compared with the Panama zone and Mauritius :

Tables Showing the Number of Employees and Annual Death Rates per 1,000 from Disease Only — Ending 31st December, 1941.

European Employees (White Employees)

	Roan		Mufulira		Panama		Mauritius
	No. Employees	D. R.	No. Employees	D. R.	No. Employees	D. R.	
1935	584	1.7	379	2.6	3376	4.15	26.5
1936	525	5.7	329	nil	3497	5.43	26.4
1937	693	5.7	453	6.6	3653	3.8	28.8
1938	808	6.1	507	7.8	3645	3.8	29.9
1939	803	6.2	840	3.5	3883	5.1	28.0
1940	850	nil	1043	nil	5620	3.5	25.5
1941	912	3.29	931	2.1	7338	2.8	29.2

AFRICAN (or Coloured) Employees.

	Roan		Mufulira		Panama	
	No. Employees	D. R.	No. Employees	D. R.	No. Employees	D. R.
1935	4486	5.35	2801	6.0	9053	11.6
1936	4289	4.65	2749	2.9	9386	7.67
1937	6223	6.43	4277	9.58	10,170	9.64
1938	6880	4.94	5085	9.4	10,166	9.54
1939	6870	3.49	5386	5.7	11,852	9.87
1940	7197	2.22	6718	4.6	19,793	6.11
1941	8553	3.63	7451	4.6	26,417	5.4

When I went out in 1929 the death rates amongst Europeans was 22.4 and Africans 32.3. In one year it dropped to 15.2 and 15.8

The camp sites had already been chosen and the camp partly built, so that I had to make the most of a rather difficult situation. In the case of the largest mine, Roan Antelope by name, we had to control 30 square miles and the cost was about £ 30,000 before the work was complete.

As the mine was to cost £ 4,500.000 before any copper was produced and it started as the seventh largest mine in the world, this was considered reasonable, whereas careful site selection would have cost considerably less.

In 1931 I was asked to advise on sites for the erection of camps for the construction of the great bridge over the lower Zambezi. Here also £ 4,500.000 was to be spent on the bridge I choose two sites, one on the north bank and one near the south bank. The cost of control was about £ 1,000 and the result was that of 60 imported Europeans not one in 3½ years acquired malaria and the African labour force enjoyed excellent health. The site where the bridge was built near the junction of the Shiri River with the Zambesi had been referred to by Dr. Livingston as the most unhealthy in Africa.

By comparison, when the bridge over the Pongwi near Beira was built, a double staff was set out, it was never possible to have even a single staff working. The cost of replacement of staff was large and the mortality high. No malarial control was undertaken.

I have given you these illustrations from my experience, so that you may be convinced that intelligent applications of the known methods can produce almost complete elimination of malaria under the most difficult conditions. Conditions which are far worse than anything which exists in this Colony. In the African illustrations that I have given, the vectors are the same as in Mauritius.

Here I think it is as well to remind you of the anti-malarial success in Mauritius which is quoted in most text books on the subject.

When Sir Ronald Ross came here in 1907, he found Vacoas and Phœnix full of malaria, black water was common and spleen rates ran up to 100% Clairfond marshes were drained and for 35 years that area has remained healthy. This success seems to have been forgotten or ignored. If Ross's advice had been followed, as a consequence of this success, malaria would not be known in this island to-day.

Recently the Army Anti Malaria Unit, in a very short space of time, under Major Jepson, with the help of the Anti-Malaria staff of the Department of Medical and Health, has had remarkable success at Tombeau Bay (notoriously unhealthy) and elsewhere.

I hoped I have convinced you of the possibility and the necessity and it is now up to me to show you how to set about the work. I will start with:

The Mosquito:

There are 1,700 different kinds of mosquitoes in the world. When Ross made his famous discovery this was not known, in fact very little was known about mosquitoes. Ross described his vectors as spotted or dappled winged mosquitoes.

Of these 1,700 only 170 are Anophelese and of the 170 only 17 are vectors.

There is a further reduction, in that only the female mosquitoes bite. The male mosquito can always be recognised from the female because he is bearded like man. On both sides of the biting apparatus (proboscis) the male has furred plumes (palpi). The male waits near the breeding ground and does not fly after the female when she goes for her blood meal. If males are found in houses, it can be taken for granted that the breeding place is not very far away.

In Mauritius there are four Anophelese.

1o. *A. Mauritianus*, a large black Anophelese the ends of whose hind legs are white. This is not a carrier and breeds all over the island.

2o. *A. Maculipalpis*. This mosquito is not common and breeds in sunlit seepages. Alone it could not maintain malaria in the colony although it is a vector.

3o. *A. Gambiae* (formerly *Costalis*). This is a large brown mosquito. A deadly carrier which breeds in any sunlit water, particularly puddles, rock pools and anything which resembles similar conditions. It will also breed in slightly saline water.

4o. *A. Funestus*. A small black Anophelese. A strong flyer and as deadly as *A. Gambiae*. It breeds in any gently moving and lightly shaded water.

You may have heard of what is called " Species Sanitation " which means getting rid of the dangerous mosquito and not worrying about the others. Port Swettenham is an example. It will be seen from the descrip-

tion of the breeding places of the local anophelese that practically all descriptions of water are dangerous and that "Species Sanitation" is not possible in Mauritius.

The Director of the Medical and Health Department, Dr. Rankine has laid it down, and I think very wisely, that our war shall be against all mosquitoes.

Culex and Aedes are responsible for dengue, filariasis and (if it comes here) yellow fever.

You have probably heard something of the flight of Mosquitoes. I have recently been told that they flew 80 miles into the desert and bit our troops. This, I frankly, do not believe. Stained mosquitoes have been known to fly 14 miles but normally about the same equivalent of mosquitoes fly this distance as human beings go to the north pole. In nature the female mosquito flies just far enough to get a blood meal and the vast majority of mosquitoes only fly a few hundred yards during their lifetime.

In Asia and elsewhere it has been found that usually half a mile of protection is sufficient but this is not the case in Africa owing to the presence of *A. funestus* which, unfortunately, has been imported into this Island. In this case one mile of protection is necessary. Exceptionally where great swamps exist this has to be extended but not such swamps exist in Mauritius.

It follows that the nearer the breeding place, the greater the danger. Often a man-made nuisance in the garden is a greater danger than a river half a mile away. Protection should be extended in concentric circles until the required distance has been reached.

It is a common mistake to extend the area of protection without making absolutely certain that the source of breeding is not within the protected zone. Very careful and thorough search must be made, throughout the seasons, until every possible source of breeding has been traced and neutralised.

The female mosquito has to lay her eggs every two or three days, so that the further she has to fly the less is the chance of her returning or surviving her natural enemies.

From the time the female mosquito lays her eggs, through the four moults and pupation to the adult, in normal warm weather takes 10 days. As the weather cools off this process takes proportionately longer.

It takes ten days for the parasite to develop in the mosquito after it has been infected. It has to find some person with their blood in the right condition, that is, it has to get the form of parasite known as a gametocyte, which is compratively rare. It is more easily found in the blood of children who have not yet developed a tolerance to the disease or in the blood of adults who have no tolerance, for instance, strangers from overseas.

It takes ten days for the blood of persons bitten by infected mosquitoes to be in a condition to reinfect Anophelese.

The whole cycle must be, in the shortest possible period, at least 30 days. So it follows that to maintain malaria, the insect which conveys it must have a life considerably in excess of that period.

It is known that mosquitoes will survive a winter or the dry season and mosquitoes have been kept alive in captivity for four or five months. The lesson to be drawn from this is that once control has been undertaken, the utmost vigilance must be maintained to see that no generation of mosquitoes escapes because they may carry infection for months. There will be a time lag between the birth of the mosquitoes and the outbreak of malaria, so that the source of infection may have disappeared before one is aware of the danger and it may reappear when conditions are again right.

I should warn you that once control has reached the stage when most persons are free from malaria the population will lose their tolerance and neglect of control may be serious.

An outbreak of malaria amongst a non-tolerant population in 1934-35 caused the deaths of 80,000 persons.

Although the infection rate of mosquitoes sometimes reaches a very high figure it is not generally high but an infection rate of 1% will cause serious malaria.

The object we have in view is to reduce the number of mosquitoes and thereby the number of vectors. If the number of vectors is reduced, the number of reservoirs (i.e. persons with gametocytes in their blood) will be reduced. With fewer reservoirs the percentage of infected mosquitoes will come down. This process is continued until there are not enough vectors to infect man and not enough reservoirs to infect mosquitoes. This is the condition which has been reached in England although *A. Maculipennis*, a common vector in the northern hemisphere, is present. After the war of 1914/1918 many soldiers returned to England suffering from malaria and this influx of reservoirs temporarily put up the indigenous cases from 1 to 500.

It will now be seen that we have to (1) establish a zone of one mile round all habitations in which mosquitoes cannot breed and (2) that when control is routine it must be undertaken within the incubation period of 10 days (normally once a week).

What I have said about the mosquitoes, as simple as possible, is the work of numerous scientists, brilliantly carried out in many climes. The actual carrying out of the work, necessary to put in force their discoveries is the work of practical men under scientific guidance. It is here the Planter, Miner, Sanitary Officer, Public Works Department Officer, who have done so much all over the world, to put theory into practice.

Our first line of attack is oil and occasionally Paris Green.

Oil kills in four ways :

1o. The larvæ of mosquitoes are air breathers and are so balanced by nature that they can pierce with their breathing tubes the surface of

the water to breathe. A film of oil alters the surface tension and the mosquitoes are unable to reach the air and drown.

2o. When struggling to reach the air, oil will enter the breathing tubes of the mosquitoes. This will suffocate the mosquitoes.

3o. The oil recommended for its spreading power and its toxic properties is Malariol. It is sold in Mauritius by Messrs. Blyth Brothers & Co. It has been evolved by the Shell Co. and the Ross Institute after prolonged research.

This oil paralyses the nervous system of the mosquito on entering its breathing tube and the mosquito dies.

4o If a female mosquito tries to lay her eggs on oiled water, she seldom rises again.

Oil must be spread on the water to form a complete film which must not be broken by weeds, debris or algae.

My practice was to send a gang of women and children ahead of the oilers to clear away obstructions.

The oil is best spread by means of a sprayer. The one I recommend is the Ross pattern, Four Oaks Sprayer, which is not as yet available, in Mauritius but can be seen in use by members of the Anti-Malaria Unit. The oil should leave the sprayer in a finely vapourised condition and be sprayed on the edges of the water, half on the ground and half on the water.

The mosquitoes prefer very shallow water, in which their enemies cannot swim, such as tiny backwaters, hoof or foot prints, etc. which are found on the edge of the water and are difficult to reach by any other means but a sprayer. Sprayers have been ordered and will be made available on arrival.

In the meantime, there are substitute methods which are fairly efficient. One is to soak sawdust or like material in Malariol and to throw handfuls in puddles, pools and on the edges of streams. A film of oil spreads from the oil soaked material.

It is not necessary to put on great quantities of oil. A film 1/1430 inches thick is sufficient and is equivalent to an iridescence on the surface. The sprayers are usually supplied with too large a nozzle, so that it is advisable to fill the hole with white metal and rebore the size of a pin hole.

The other method is to have one labourer with a can of malariol sprinkling a few drops of oil with a brush or similar implement on the water, followed by another labourer who vigorously sweeps the water on to the sides or banks thereby spreading the film of oil into all crevices and backwaters. This method has many shortcomings until after the land is drained as it cannot be used on small seepages.

It is obvious that it is not desirable to oil masses of water and the

water surface to be put under control should be reduced as far as possible, especially in urban areas.

This can be done by grading the surface, scupper drains, deep drainage and French drains. Puddles in towns can be got rid of by the sweepers spreading the water over the surface so that it can be absorbed or can dry quickly.

Scupper drains and grading are only of use in getting rid of rain water. In Mauritius on all but the black soils the absorption is so good that little rain water lies about. The greatest danger lies in the water arising from springs.

It is commonly said that springs rise out of the soil but a little thought will show that, except in rare occasions, this is impossible. There is always water moving down through the soil and owing to circumstances, such as high water table, a rock or lava formation, or a change in the texture of the soil so that the water moves faster in the upper stratum than the lower, the water is forced to the surface. In any case the water comes from the higher ground. It follows that the springs can be tapped by cutting a drain just above the highest appearance of the water to a sufficient depth. This means cutting the drain parallel with the countour and leading the water to the outlet. Herring bone drainage is only useful when dealing with water logged soil free from springs.

The secret of drainage is depth. No drain is worthy of the name under 4 feet deep. The efficiency of a drain is proportionate to its depth measuring from the surface of the water in the bottom of the drain. Drains should have a section large enough to carrry the wet water flow in the bottom of the drain with ample freeboard so that the surrounding country can be denuded of surplus water and be in a position to absorb subsequent showers when they fall.

The water table rises at a slope, depending on the consistency of the soil, from the surface of the water in the drain, so that the efficiency of the drain at a distance from its bank is proportionate to its depth. Drains of 6 to 8 feet deep are far cheaper to upkeep and control than numerous drains of a lesser depth. Anti malaria drains should be V shaped with a slope, in ordinary soils, of one in two. This insures a concentration of water as the country dries out, thereby making it impossible for mosquitoes to breed and it prevents silting. In drains with wide bottoms, as the country dries, pools will form and the slow moving shallow water will make ideal places for mosquito to breed.

Recently some good drains have been cut at Engrais Cattan near Curepipe which are worth inspection.

Anti-malarial drainage does not cater for floods which, they run off quickly, are beneficial rather than otherwise (natural flushing).

In Malaya it is usual to cut down routine cost of control by subsoiling the spring areas which is done by laying earthen pipes in the bottom of the drains. In this Island there is not the clay, plant or trained

personnel to make the pipes but there is ample stone. French drains which are made by filling the drains at the bottom with large rocks or building rock tunnels and covering the top foot or two with fine chips are nearly as sufficient. There are some excellent examples of this work on the north slope of Corps de Garde built 17 years ago and on Candos built 7 to 8 years ago. More recent work has been done by the Army Unit and deserves inspection.

All rivers and streams should be canalised, that is, the obstructions in the stream should be moved to form well defined banks so as to concentrate the water and avoid pools. The most dangerous type of streams are those which, at certain seasons, dry out. While they are drying, pools will form and fish will be absent. These pools are a prolific source of *Anopheles gambiae* and are very easily controlled by routine oiling.

Where the water is perennial, flushing can be resorted to with excellent results Flushing is done by draining back the water and at regular intervals letting the water out with a rush. This can be done by hand manipulated or automatic devices. The volume of the water to be let loose depends on the size of the river and the distance of efficiency will depend on the fall of the river and the amount of water let out. The effect is that the larva are washed from their safe little refuges into the body of the stream where they are either drowned, washed, left high and dry on the fall of the wave, brought in contact with fish or carried away to a safe distance. Natural flushing is no doubt of great benefit to the island in the steep and narrow rivers which cut up the island.

Fish are useful where they can swim freely and can see their prey. In tanks, 'bassins', reservoirs, etc., where the edges are sharp and free from weeds, where the surface is free from debris, algae and reeds they are fairly efficient if in sufficient numbers. "Dames Cérés" and "Millions" are both useful fish.

Wherever water runs, the edges must be kept clean. The shade suits *Anopheles funestus.* The water is slowed up and the vegetation offers protection to the larvae. Much of the relatively good health in Plaines Wilhems is due to the care the Department of the Medical and Health have taken in canalising the streams and rivers and keeping the edges near the water clean.

Rock pools are a great danger. To avoid the control of them by oiling, either they should be filled with concrete or have channels chiselled so that the water can escape. The former is probably the cheaper method.

Shade is a great help in the control of malaria, principally to reduce the cost of upkeep. You have no doubt often noticed that under heavy shade, nothing grows on the ground. This is equally true of water. A very good example of this is to be seen from the bridge leading to the Botanical Gardens in Curepipe near the offices of the Forest Department. Shade over water should be preserved and encouraged by all means. The cost of upkeep will be reduced in portion to the amount of shade and *Anopheles*

gambiae will not tolerate shade. The shade must be provided on the sides as well as from above.

There is another kind of shade which will prevent even the breeding of *Anopheles funestus* but it has to be dense. So dense that the sky cannot be seen when looking from below. In India and elsewhere *Lantana* is planted on both sides of the drain and clipped to form a hedge which completely covers it in. The plant used must be useless as fodder and firewood and sufficiently thorny to make progress through it unpleasant.

Swamps, such as they occur in this island can be dealt with in several ways. They can be filled, drained or impounded or dealt with by a combination of any of the three methods.

Impounding is to convert the swamps into a lake and so keep it that fish and wave action can be used as control.

Some swamps below sea level can be made into salt water lakes by letting in the sea, and, if necessary, diverting the fresh water at a higher level.

There is danger on the sea board that pools may be mistaken for those left by the sea, whereas they are kept filled by springs from the main land. These coastal springs may account for much of the evil reputation of the sea-side.

What I have said will give you a rough idea of what has to be done to control malaria. In many parts there is very little to do. For instance the northern plain of Mauritius is entirely free from natural breeding places and malaria is only caused by the neglect and carelessness of man. In fact man in his ignorance has caused and is still causing the majority of malaria in Mauritius.

In this connection faulty irrigation is one of the main causes of malaria. Leaks from channels must be stopped and put under oiling control until work can be done. The use of water must be so controlled that no nuisances can arise. This applies equally to the great sugar Estates and to the small market gardener. A leaflet by two local experts on irrigation will shortly be issued for general guidance.

It is impossible in a lecture to cover all the ground in the question of the control of malaria. The " Handbook of Malaria Control " is now being translated into French and will give further guidance on the subject.

No doubt the ingenuity of the Mauritians will find many ways of solving their problems. For instance the pipe line to an old disused factory has been used to irrigate the gardens of the staff and labour force causing many nuisances, particularly where watercress and " bredo songe " beds had been constructed. By putting a cock in the pipe line above where it was tapped for irrigation and by turning off the water weekly it is possible to dry out the land and kill the larvæ without greatly interfering with the benefits derived from this supply.

In this connection I should mention that the ground must dry be-

cause larvæ can live in wet mud as they are air breathers but soon die if their bodies dry.

I am convinced that malaria need not exist in Mauritius, at any rate to such an extent that it affects the death rate. It is up to the Mauritians to support the Government, the Malaria Control Board and the Department of the Medical and Health in their war against Mosquitoes.

Plans are being made and will eventually mature but there is no need to wait for these, where man-made nuisances exist.

If there is the will, there is a way.

Réunion du 12 Mai 1944

Présidence de M. S. Staub.

Étaient présents : MM. C. R. Harrison, Dr. A. Rankine, A. Darné, R. Pilot, P. Houareau, F. Feuilherade, S. Dupont de R. St. Antoine, Ph. Tennant, J. Jauffret, F. North Coombes, L. Fayd herbe, J. Brouard, Ph. Genève, Fr. Mayer, R. Lincoln, O. d'Hotman, P. Halais, J. Vinson, Major W. F. Jepson, R. d'Hotman, A. Carles, P. G. Anthony, G. P. Langlóis, G. Park, G. Ducray etc.

Discussion au sujet d'un mémoire de Mr. C. R. Harrison *sur*

LA MALARIA

*circulé au préalable parmi les membres de l'Association**

The President opened the meeting and stated as follows :

Gentlemen, it is my privilege to preside over this meeting assembled here to-day to hear Mr. Harrison who is now so well known to the planting community that he does not require any introduction. Advance copies of his lecture have been sent to most of you and you must have noticed the masterly way in which the Malaria problem is treated. I think that the visit of Mr. Harrison here in Mauritius has been a piece of good fortune and I very much hope for us all that the fullest advantage of his experience will be taken with the least possible delay. I now call upon Mr. Harrison to speak.

Mr. C. R. Harrison : Gentlemen, you have had my lecture and I do not propose to go over it, but I have come here to listen to you speaking. I do not want to hear my own voice to-day except in reply to questions. Anything you can tell me that you do not understand is going to be a great help to those who come after me in saying in what direction I have

* Le texte de cette commuincation paraît *in extenso* à la p. 133

failed to be understood. I want everybody to be profound believers that malaria can be prevented.

The difference between the man who believes in Malaria Control and the one who does not believe, is that the one who believes will do anything in his power to find out mosquito breeding places and will destroy them, whereas the man who does not believe in Malaria Control will send his gang of labour round just to let them get rid of their ration of oil and get back to their dwellings.

I am very pleased in being at this meeting to-day because being a planter myself, I have the greatest respect for planters and with the co-operation of all concerned I hope within five years, and I am sure within ten years, that malaria will cease to exist.

The President : Mr. Harrison, there is one question I should like to ask — it is about the cane fields. Do you think that the cane leaf is not a habitat where mosquitoes can breed and if so on what scale?

Mr. Harrison : The leaves of plants generally—not only cane leaves—do occasionally breed Culex and Aedes, and on very very rare occasions Anophelese. They are not an important factor in the malarial compaign—wherever we got rid of malaria we had done nothing about plant leaves. It is advisable however to fill hollows in tree trunks with cement but it is not an important thing from the malarial point of view. In a well known case on the West Coast of Africa they had some harbour works being constructed on barren country without any fresh water supply, and surrounded all by the sea. Fresh water had to be imported and yet the health was appalling. Eventually mosquitoes were found breeding in the top of coconut trees Every night there was a heavy dew and water was retained between the fork and the main stem ; but that is an exceptional case. In other parts of the world where I have controlled malaria no step has been taken whatever to deal with vegetation.

Mr. R Lincoln : I would like to draw your attention to this paragraph of your paper which states : — " The object we have in view is to reduce the number of mosquitoes and thereby the number of vectors. If the number of vectors is reduced, the number of reservoirs (i.e. persons with gametocytes in their blood) will be reduced " Therefore it is possible that during a certain period to put for instance the whole population, through a legal measure, under the influence of say quinine ? and if it is possible, what will results if such measures were taken ?

Mr. O. R. Harrison : Control by drugs, well, is not a failure. In parts of the world where you have no option but to keep yourself alive by taking drugs then by all means take drugs.

When I was in Malaya men, women and children received 10 grams of quinine per day in liquid form. They had the idea that quinine prevented children to be born — it was malaria that did that quite honestly — and the women particularly, used to go to their camp and put their fingers in their throat.

The President : I come back upon that question of nature made nuisances and man made nuisances You have answered my question about trees and canes, now what about the empty shells of "couroupa." Do you think these could be a breeding place for anophelese ?

Mr. C. R Harrison : They may breed there — Major Jepson found them, I think, in those shells.

Major Jepson : You might possibly find eggs being laid but this is the maximum we have found. I do not think that they would develop.

Mr. C. R. Harrison : I think myself that if you have an opportunity of destroying a shell it is just as well to do so. The destruction of shell is rather a big job but if you come across one it is better to smash it away. My object is to get rid of as many mosquito s as possible. There will always be a few breeding places here and there but that will not maintain malaria.

Mr. A. Darné : What do you think of pH control of stagnant waters as a means of reducing malaria ?

Mr. C. R. Harrison : I think myself that Major Jepson is the most suitable man to reply to this.

Major W. F. Jepson spoke about a method which can succeed in practice and which consists in filling hollows in rocks with chopped grass, when the rain comes the water in the hollows is unsuitable for the breeding of anophelese.

Mr. G. P. Langlois : There is an important aspect of the question and that is villages near Sugar Estates. I believe they are the worst thing that may be near Sugar Estates. There is a certain amount of control done on estates and absolutely nothing in villages.

Mr. C. R. Harrison : I think that Dr. Rankine is here, he will be the best person to give a reply to this, but I can assure you new legislation will deal with that situation but I think that Dr. Rankine is the best person to reply as to the policy that is going to be undertaken.

Dr. Rankine informed the assembly through the President that he was going to answer to the question at a later stage of the debate.

The President : Now Mr. Harrison, I noticed that you have mentioned in your paper that fishes controlled mosquitoes in a certain measure. Do birds such as wild ducks and so on fight the larvae to an appreciable extent ?

Mr. C. R. Harrison : There are many enemies of the mosquitoes. None of them have in nature succeeded in controlling Malaria they all help. Ducks, wild and tame, and all those animals which suck water through their bills can destroy enormous numbers of larvae.

The President : I am speaking under the correction of my friends Lincoln and Halais but I believe that the soil in the higher parts of the island for instance near Curepipe is acid. Don't you think that this is a factor which prevents the occurrence of malaria near Curepipe ?

Mr. C. R. Harrison: I am not prepared to accept that statement without some very definite researches but I do not think it is the case because quite recently anophelcse have been found at Curepipe — probably not in sufficient number to matter but they are there. Recently at Vacoas A. Gambiae were found in a spring and certain measures were taken. At the moment I rather think that breeding is not much in that part of the area, not nearly so much as it is round Port Louis on account of temperature. I think the water temperature is 22 °C there. When the temperature gets near 16°C breeding practically ceases. The absence of anophelese in this area in my own opinion is due to the heavy rainfall in the Curepipe area ; you have thus natural flushing. On the other hand right in the middle of Curepipe I know some swamps that are ideal for mosquito breeding and yet I have not found any in them. I do not know what the reason is — but at Alma as you know there has been an outbreak of malaria in 1942 and it is situated in the same condition as Curepipe.

Mr. P. Halais : Has shade to do something with the temperature of water and otherwise the breeding of mosquitoes ?

Mr. C. R. Harrison : I have not gone into that question as to what extent shade has an effect on the water ; it must have if the stream is very shaded.

The President : With respect to that deep shade you have recommended you spoke about Lantana which is called " vieille fille " locally and which is useless as fodder or firewood. I believe there is a disease on " vieille fille " and thus it may not give here the good results as it has given elsewhere. What substitute plant would you suggest under local conditions ?

Mr. C. R. Harrison : A report has been drawn up by some people in this Island, I think Mr. Wiehe and other members of the Department of Agriculture have given a list of suitable trees and shrubs for the various purposes. That is definitely an angle for experiment in this country.

Mr. Harrison asked if the members all understood the importance of drainage.

The President : The first step with respect to drainage is I believe, not the drainage of marshes but the draining of land on which pools of water are formed when there is heavy precipitation. What are the appropriate means of dealing with that general problem ?

Mr. C. R. Harrison : If a pool forms because the soil is non-absorbant the soil may be such for two or three reasons. The texture of the soil, in black soil and the rate of absorption is very slow ; then you may have holes where water deposits. Also where the soil is hardened by traffic and walking, the surface is closed up, it is beaten hard and the water does not go through. Well in these two cases you can get rid of the water by what are called scupper drains — a little cut in the ground and the water is spreaded away over the slope — in most soils of this country it will vanish very quickly — on the hard soil round camps that is the temporary measure that one could take. There are very few places in this country where the land is flat as the water could not flow away.

With regard to water standing in the black soil I have tried to deal with it in my lecture. Water will stand in many holes. There is a very good example of what will happen at Bell Village — there were a great number of hollows there, made by men and nature. They have been partly filled by skimming the surface and partly by having little canals to let the surplus water away so that the soil has to do as little work as possible.

The President : What are your views on forking ?

Mr. C. R. Harrison : Forking will undoubtedly do in most soils. Another method would be a system of drainage proper. I am not prepared to dogmatise on how far apart the drains shoul be, but you can take a rough standard of 100 feet to start with ; now drain your hollows into that drain using the land from the drain itself to fill as many hollows as possible. I have spent many years draining land and I think I can speak with some authority as far as the agricultural point of view is concerned. Water logged lands looked upon as useless will grow good crops if properly drained. You will find that the texture of the soil after a few years will change entirely. I have in mind the place in Mauritius on the slope of the " Corps de Garde ". Some French drains were made there, the soil was considered useless and it is now growing good crops of sugar cane.

I think that when you do drainage on your blacksoils in a year or two you will get your money back.

Mr. A. Darné : With regard to French drains do they not get blocked very easily ?

Mr. C. R. Harrison : I do not think that there is anything in the world that does not require a little upkeep now and again

Major W. F. Jepson : With regard to French drains there is an important point — some kind of grass has to be grown on the bare land so that it is consolidated because otherwise it will crumble down within a single shower of rain.

The President : Now Mr. Harrison, on what scale can artificial flushing be done in Mauritius ?

Mr. C. R. Harrison : Artificial flushing should be done preferably in small streams. I saw an ideal one at Vallée des Prêtres — behind Port Louis. I say that 90% of the streams could be flushed. The irrigation rights have been carefully set out in the laws we are drafting and no flushing will be put until the people concerned have an ample chance of seeing that their rights are not interfered. We do not use the water, we only move it from one pond to another along the stream.

Dr Rankine : Mr. Chairman, Gentlemen, I am sure Mr. Harrison will not object to my modifying a statement he has made. He was asked a question about mosquitoes breeding in trees, and leaves. No blame can possibly attach to him because the example I am going to talk to you about is so recent that Mr. Harrison certainly has not had the opportunity of finding out about it.

In the West Indies it was believed that we knew exactly what species of anophelese were vectors of malaria and in a certain area despite

the control measures, malaria developed in a very high incidence, and it was discovered that one species of anophelese had been overlooked in the West Indies which was found to breed to a considerable extent in Bromeliads growing as epiphytes on the Immortelle tree. I think however that you can take it quite definitely that it is not the case here.

The question I was asked to answer is very pertinent and I am glad that point was raised. Mr. Harrison has said that if estates look after their own property they will see a very marked difference. I may say that 50 or 60% of estates labourers do not live on the estate, and the question of the health of the neighbouring villages is therefore very important. It is not for me to say anything about malaria or malaria control in the past, but I can assure you that it is the intention of Government, it is mine, I may say within this respect, to ensure that areas in the immediate vicinity either of camps or of towns will be rendered safe so far as malaria is concerned. Unfortunately, at the present moment to undertake that is beyond my powers given the material that one has at one's disposal. But you may not be aware that at the present moment in fact for the past twelve months we have been training personnel for that type of work when Major Jepson's Unit disappears having accomplished its labours. These individuals will be very considerably re-inforced, and I have the assurance of the Governor that I will have people who are competent to do work of this kind.

For the present the line which I am taking is this. When an estate, of its own will, or on the pressure of Mr. Harrison, is undertaking works and needs help from the Department in regard to something on the estate, the Department is entirely at its disposal. I am glad to say that I have had requests from three managers already and in all three cases they have expressed their complete satisfaction with the assistance which they got.

As for the villages themselves, I can assure you that as soon as I have got the required staff, they will be looked after. I am not to repeat what I have said at the Dodo Club but I will say this : that there is a certain legislation being drafted which is going to the Advisory Committee next week before going to the Government. That legislation is there to enable us when necessary to invoke the powers of the law and to see that people do what they are requested to do, but as I say I am very hopeful that the calling in of the law will be the exception rather than the rule. Any estate which has been doing its best and is doing its best and finds that any particular village in the immeniate neighbourhood requires shaking up I shall be only too glad if that estate will mention the matter to me and I shall send someone to look after it.

The President : Gentlemen, I wish to thank Mr. Harrison and to congratulate him on the debate which he has conducted so ably.

From what I have heard to-day I am convinced that the day will come when the grinning face of malaria will only be a recollection to the people of this Island. But in order that that result should be reached we must follow the example of Mr. Harrison when he was a planter and must set to work immediately with unflinching determination.

Réunion du 2 Juin 1944

Présidence de M. S. Staub.

Etaient présents : MM. A. de Sornay, A. Moutia, P. O. Wiehe, M. Carles, J. Carles, J. Duhamel, Ph. d'Arifat, G. Masson, N. Craig, G. C. Stevenson, J. Jauffret, F. North-Coombes, F. Berchon, A. d'Emmerez, H. Scott, M. Souchon, G. Mazery, P. Houareau, L. Fayd'herbe, Capt. A. North Coombes, G. Orian, P. Némorin, C. Noël, R. Antoine, H. Vaudin, S. Belcourt, R. Mamet, R. Rivalland, R. Thélémaque, P. de Gersigny, P. Bonieux, H. Léclézio, R. Bouvet, S. et J. Dupont de R. St. Antoine, J. Cantin, F. Nadeau, A. Delord, C. Courtois.

LUNAR PERIODICITY IN ANIMALS

by

J. F. G. WHEELER, D. Sc., F.L.S.
Marine Biologist, Mauritius.

The work I propose to put before you deals mainly with observations of the vertical migratory movements of a prawn, *Anchistioides antiguensis* (Schmitt), which occurs in Bermuda and the West Indies. Two papers on these observations have been published. I shall then refer briefly to some recent work of mine on the fish, *Teuthis corallina*, more easily recognisable under its local name of "Cordonnier gros-race", which suggest that a somewhat similar phenomenon may occur in fishes here and may perhaps be made use of in the economic rationalization of the fishing industry.

The genus Anchistioides was instituted many years ago by Paulsen for certain decapod crustacea found in the Indian Ocean. The genus was then almost lost sight of, but was rediscovered by Kemp at the Andamans. One may predict that it occurs at Mauritius also, though, as you will see, its discovery quite likely depends on a slender chance unless its peculiar habits are understood.

A favourite evening amusement at the Bermuda Biological Station was to watch the water at the jetty under a powerful electric light suspended two or three feet from the surface and shaded to illuminate a semi-circle two feet or so in radius Fishes, squid, various crustacea and worms were often seen and sometimes captured. While thus engaged one night Dr F. A. Brown, Jr. then of Harvard, noticed some faintly opaque organisms moving at the surface. With a small dip net he caught one or two and found that they were almost transparent crustaceans of an unknown species. Collections on following nights added to the total until there came a period when watching was in vain. They came again however, after this blank period; and Brown, noting that the dates of the majority of his captures coincided with the time of the new moon, began to write a description of a new genus and species of Palæmonid which was to be found swimming only at the new moon phase of the lunar cycle. When he left the Station I carried on his observations. Meanwhile specimens sent to Dr Isabella Gordon of the British Museum were identified as

Anchistioides by Dr Kemp himself and Dr Gordon traced the connection with Schmitt's new species *Periclimenes antiguensis* of the West Indies, a description of which had just been published.

A record was kept from January 21st, 1935 to October 16th, 1936, in the course of which 335 observation periods of an hour or more were spent at the jetty with the light, or on the water in darkness, and more than 1100 prawns on 131 nights were seen at the surface. In 1940 some further observations were made in connection with the collection of data on moulting. This record, not previously published, is reproduced in fig. 1, It extends over four months, includes 44 periods of observation during 20 of which prawns to a total of 150 appeared. All these prawns were observed at night. Nobody has yet caught or seen a single one in its natural conditions during the light of day.

At first it was supposed that the light at the jetty attracted them. By fishing at the surface with a wire net buoyed by floats towed from a motor launch they could be caught in darkness provided that the boat moved fast.

Many efforts were made to find their hiding places by day. Trawling and dredging, fast and slow, on sand and on sea-grass produced no result. Sifting the sand and mud dug from the bottom near the jetty and elsewhere with the aid of a diving helmet was no more productive. I tried marking captured prawns and liberating them. By tying a fine cotton thread round the body behind the carapace and sticking a tiny label on a free end of the thread with waterproof cement I could trace the marks downwards in the water after one or two circling turns at the surface in the wake of the invisible prawn, but on descending in the helmet to search I was foiled by the fine mud stirred up at each step and could hardly see the bottom much less my marks.

Wherever they live the fact remains that all through the year, round about the time of the new moon, Anchistioides comes to the surface sometimes in sufficient numbers to merit the term swarming. From the extensive observations we can define the time and frequency with considerable precision. Fig. 2 shows the relative proportion of blank observation

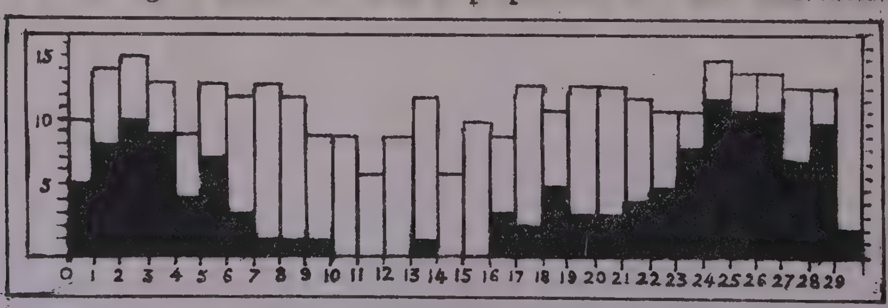


Fig. 2. The number of appearances of prawns (black) and the total number of observations on each night of the lunar month.

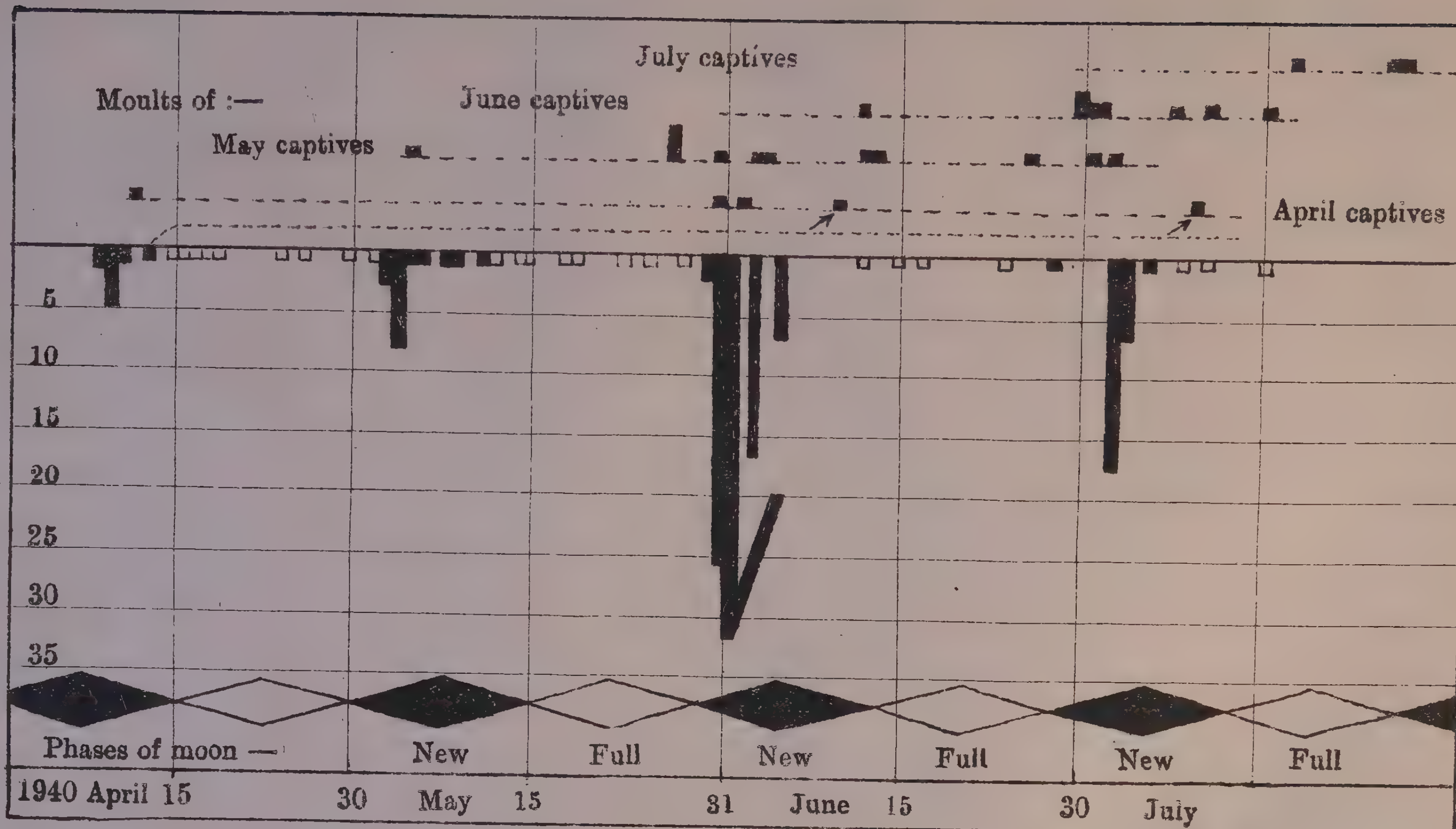


Fig. 1. Observations on the appearance of *Anchistioides antiguensis* (Schmitt) in 1940.
Period of observation without record of prawn denoted by open square.
Period of observation during which one prawn was seen denoted by filled square.

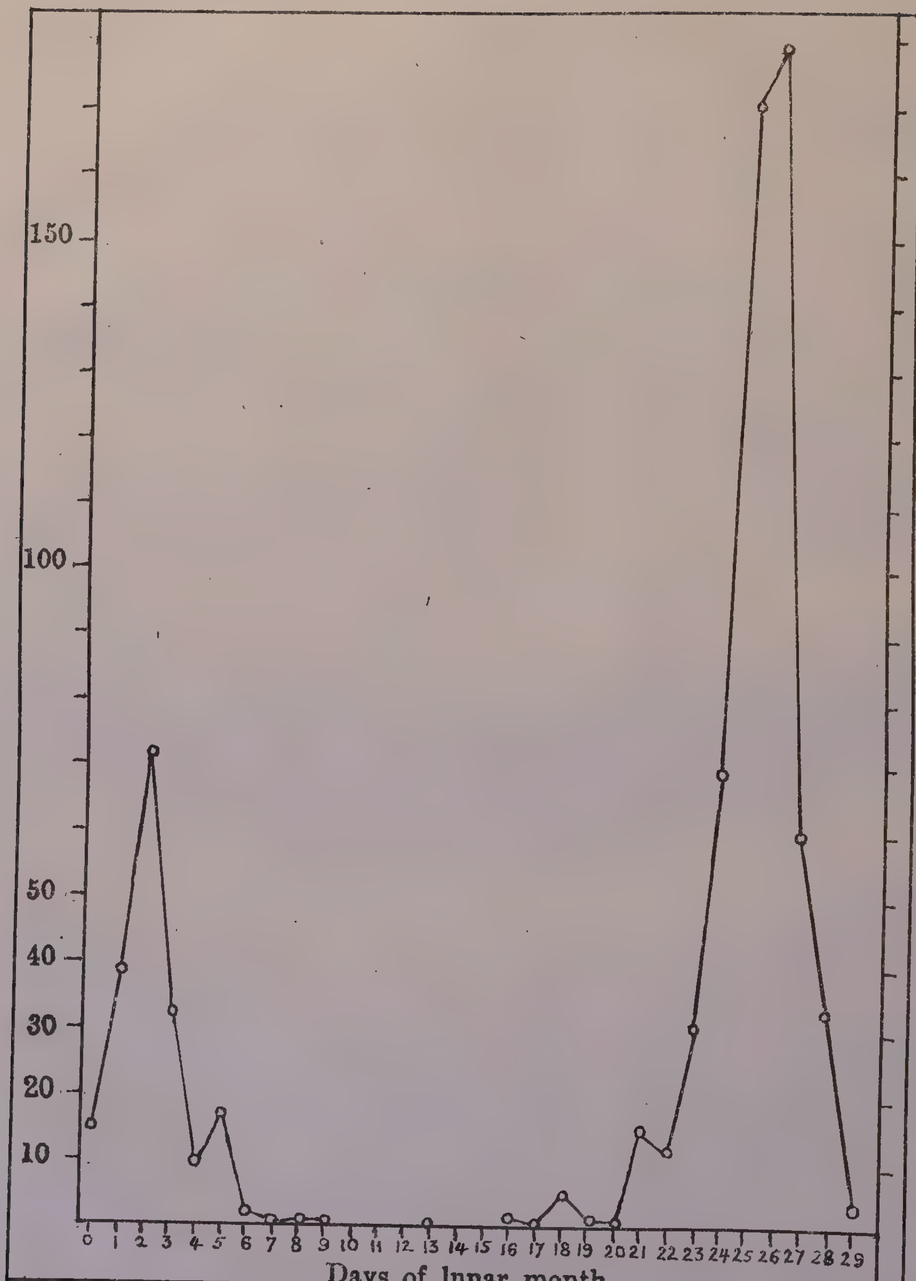


Fig. 3. Relative intensity of appearances at the surface during the lunar month.

periods to those when prawns were seen at the surface. By reducing all periods of observation to one hour and multiplying the number of prawns captured in this time by the fraction — number of appearances over number of observations — the relative intensity of swarming can be defined on each day of the lunar month (fig. 3). The frequency increases from the night of the new moon to the night of the second day, after which it declines and becomes zero on the ninth day. On the 16th night activity begins again culminating on the 26th night, then subsiding to the night of the new moon itself. This double peak over the time of the new moon is a curious feature that will be referred to later.

The prawns make their appearance about an hour after sunset which is at 7.30 p.m. in July and 5.15 p.m. in December The number usually reaches its maximum half an hour or so later and then diminishes. Sometimes, however, isolated prawns keep turning up far into the night so that the end of the period is ill-defined.

One further point must be taken into consideration. When Brown made his initial observations some of the prawns caught were females carrying eggs. This was in June. In July I found that only a few males appeared and their size contrasted strikingly with the very small specimens taken at the August new moon following. Length measurements through the year show that in July one generation dies out and in August the succeeding generation makes its appearance. Whether these sexually undifferentiated small prawns have grown from the eggs of May and June or whether they belong to the breeding season of the year before has not been discovered. This new generation grows slowly in the winter but increases rapidly in size in February, March and April, is ready for breeding in May and June and dies soon afterwards. The periodicity is manifested through juvenile and adult stages of life proving that it has no sexual significance such as is shown in the Bermuda ' Fire worm ' (*Odontosyllis enopla*) which also has a lunar periodicity, this time connected with the full moon. The well-known Palolo worm, ***Eunice viridis***, which swarms at sexual congress in such numbers and with such regularity (two days at the last quarter in the months of October and November) that special fishings are arranged at Samoa and Fiji to deal with the large quantities of a much esteemed delicacy, is another instance of a lunar periodicity connected with sex.

Ruling out sex, the factors that can influence the migrations of the prawns can be grouped as periodic and non-periodic. The former include the daily tides and alternating periods of day and night, the monthly periods of the moon the spring and neap tides and the annual seasonal changes with which are associated growth and reproduction. While growth may not appear to be a periodic factor do not forget that Anchistioides is a crustacean. These animals are by the nature of their supporting skeleton forced to cast off their integuments at intervals and hastily produce a new coat several sizes larger into which they can grow. If the intervals are regular a periodicity is established. The non-periodic factors are con-

cerned mainly with weather, the winds, currents, sea temperatures, clearness of water, with which no correlation could be found.

The direct action of moonlight being the most promising causal agent (notwithstanding the recorded fact of the absence of prawns at the surface on nights when the moon was completely obscured by clouds) certain experiments were made with captive prawns by putting them in half-shaded dishes of sea water in the full light of the moon. The prawns appeared to be completely indifferent. They would swim into the unshaded area and stay there quite happily. Even the control by the much stronger light of the sun which is deduced by the appearances after sunset, failed experimentally both by direct and reflected light. It does not seem therefore that light can be the controlling factor unless indirectly through another group of animals upon which Anchistioides is in some way dependent. Such dependence might arise through its food or perhaps by reason of its mysterious housing arrangements. The food traced from the stomach contents (the setae of Polychaet worms) was identified by Prof. J. P. Moore of Pennyslvania University as the male form (epitoke) of *Perinereis melanocephala* M'Intosh. The occurrence of these worms was recorded but no correlation of intensity could be established with the appearances of the prawns. Neither could any suggestion of commensalism with Molluscs or worms whose mode of life might exert a periodic influence of the liberties of the prawns be traced.

Comparison of tidal data with the record of observations showed also no correlation of any kind.

Growth is the remaining possibility. Anchistioides kept and fed on *Perinereis* moult at intervals in a normal manner. If hungry they may eat their cast skin partially or wholly ; and if kept together a moulted prawn is promptly torn up and eaten. A specimen isolated on October 21st, 1936 moulted on November 22nd, December 20th and January 22nd (intervals of 32,28 and 31 days respectively) and died on February 12th. In fig. 1 further data on moulting is shown. The single prawn caught on April 12th apparently did not moult in May, but did so on June 10th and again on July 10th — a thirty day interval.

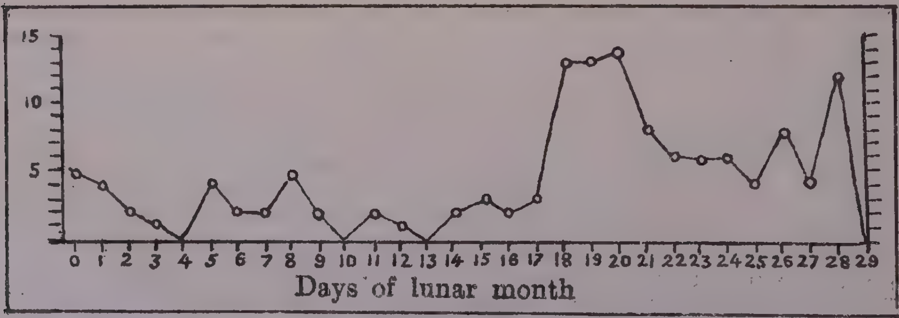


Fig. 4 Number of moults made by *Anchistioides antiguensis* in captivity on each day of the lunar month.

Records of moulting show that their frequency is greatest just before the rise to the maximum of the prawns at the surface and that over this period it diminishes. It rises again at the new moon. The two peaks of frequency of moulting thus individually precede the two peaks of frequency of appearances already described (fig 4), a juxtaposition suggestive of a causal relation between moulting and migration leading to the conclusion that the periodic swarming at the surface is controlled by an internal rhythm of growth. It is nevertheless almost inconceivable that such a periodicity should have been maintained through three generations over a period of more than two years in such exact coincidence with the lunar phases without some form of external regulation correlated with these phases.

Turning now to the Mauritian Cordonnier, of which three species have been identified, I am not yet able to put forward definite evidence of a lunar periodicity. The facts appear suggestive but more observations are necessary before proof can be given. As the periodicity is concerned with the shedding of eggs it is obvious that data can accumulate only at the breeding season, and since this occurs but once a year the process is slow. "Cordonnier gros-race" (it bears a number of local names) in the commonest species taken in nets. I began my observations on this species on October 30th, 1943. The first breeding fishes were seen on November 25th. The last, a solitary male, was taken on March 25th, 1944. The minimum length for breeding is 30 cm. In November the great majority of this species caught vary in length around 21 cm, which means that the bulk of the fish belong to the age group preceding the breeding group and thus would not have bred until the following year. The growth of this immature group has been traced during the past seven months and its average length is now 31 cm.

Fig. 5 represents the catches of mature Cordonnier gros-race (i.e. those of 30 cm. or over) taken by nets and examined for maturity from November 5th to March 4th. The number of spawning females in each of these catches is filled in in black directly above the diagrammatical representation of the lunar phases while the males in milt from the same catches are shown above. There are large gaps in the record, due mainly to bad fishing weather, but there are also indications that ripe specimens of both sexes are taken more often at the new moon and succeeding days than at the full moon. This is most clearly indicated at the beginning and end of the season. Consider the large number of matures taken on December 9th, with one male in milt among them, following the extensive spawning of November 25th, 27th and Dec. 2nd. Increase in spawning fishes is also marked in February. The single male in milt observed in March was taken on the day following the new moon among a succession of catches on four days previously and ten days following when 199 mature fishes were examined. The outline of a periodicity may well become obscured at the height of the breeding season and this may account for the somewhat anomalous figures of January 6th and 13th.

Data obtained during the coming season must necessarily be treated with reference to the lunar phases. On the figures given here breeding females occur from the 26th day of one lunar period during the season and can be caught up to the 10th day of the succeeding period. It is obvious that proof of such a periodicity would open the way to a rational enforcement by which prohibition of seining during the week preceding and the week following the new moon during the breeding season would protect the females while actually spawning, at the same time minimizing the unemployment and rotting of nets that would be caused by a completely closed season of the same length.

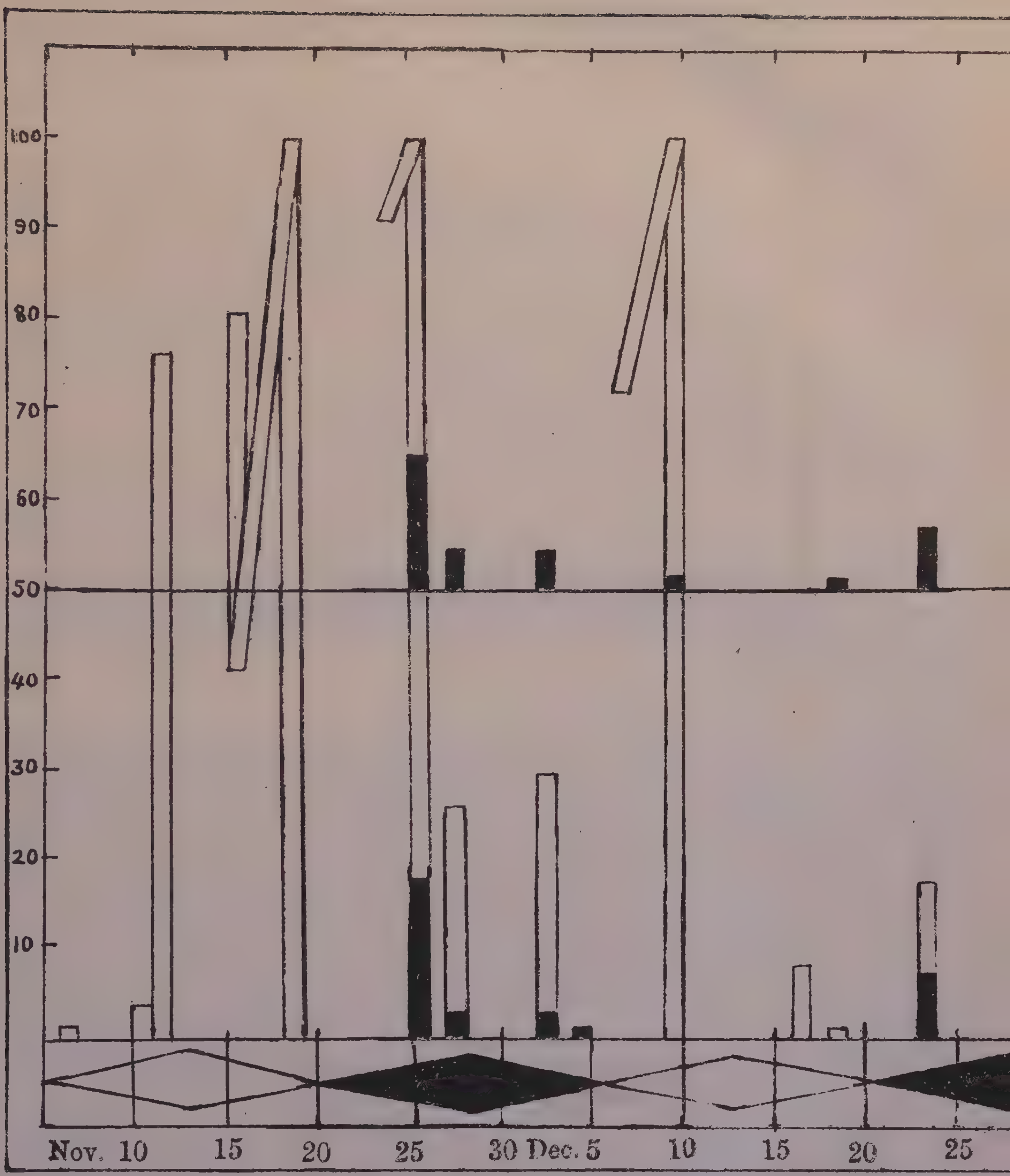
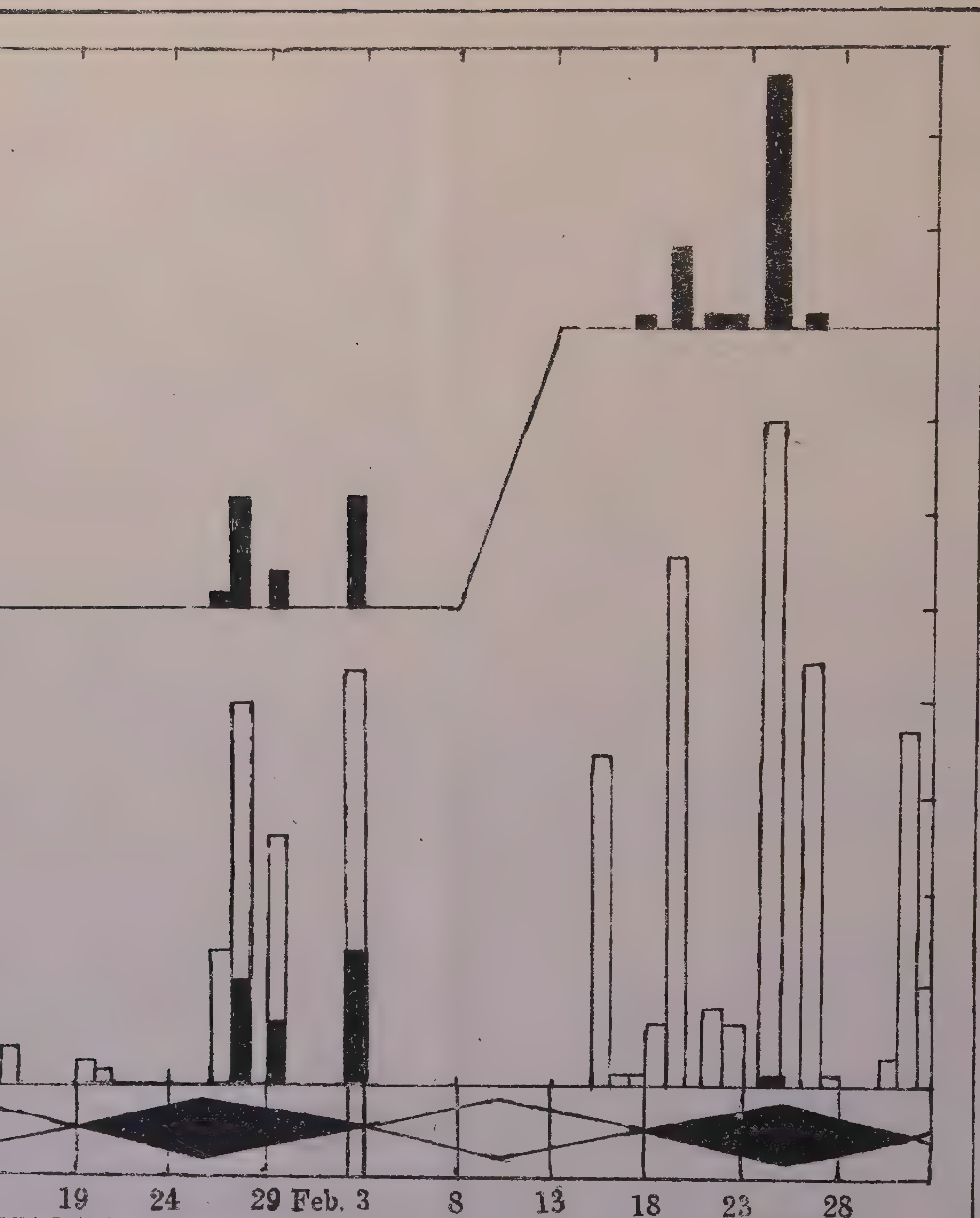


Fig. 5. *Teuthis corallina.* "Cordonnier gros-race" of Maur

Black part of block represe



fishes (30 cm. and over) represented by open blocks :
ow and males above.

THE PRESENCE OF SULPHUROUS AND SULPHURIC ACIDS IN DISTILLERY PRODUCTS*

SERGE STAUB, A. R. T. C., G. I. Mech. E., F. C. S.

The main objection of motorists to the substitution in the place of petrol of a fuel containing a high proportion of alcohol is that corrosion of parts occurs.

In the early days of the industry, in 1940, when there was no legal specifications of grade it was variously believed that corrosion of the engine was due to the presence of water in the fuel, to pyridine at that time used as denaturant, and to fatty acids.

In a paper read before the Association or Former Agricultural Students in June 1941 I pointed out that water and pyridine could be set aside as possible causes of engine corrosion which I attributed to fatty acids and it is gratifying to note that the eventual legal specifications of grade were in accordance with those which I had suggested.

The objection of motorists was based on fact and the corrosive action of certain fuel alcohols was so great as to preclude their use altogether.

It was therefore vital on the one hand to lay down some kind of legal framework for power alcohol production and on the other hand to find ways and means of producing power alcohol not only conforming with the law ; but practically neutral alcohol, thus offering maximum security to users.

A large number of analyses for acidity were performed by Mr. R. Avice and myself and it was found that the acid content of semi-rectified spirits varied a great deal. Sometimes only mere traces were to be found whereas at other times the acid content expressed as acetic acid amounted to as much as 200 mgs per litre of spirits.

Examination of data shew that in the great majority of cases alcohol from molasses obtained in sugar manufacture by a defecation process contained very little acid whereas the acidity of the alcohol was high when the molasses mashed came from a sulpho-defecation process, and it was infered that the high acidity was due to the presence of SO_2.

In order to confirm that, a large number of samples of semi-rectified spirits from defecation molasses wash and from sulpho-defecation molasses wash were analysed.

* Paper read before the Société des Chimistes on the 26th May 1944.

In the first case the total acidity of the spirits, expressed as acetic acid averaged to 4 mgs per litre and no sulphurous acid was found to be present. In the second case the total acidity of the spirits expressed as acetic acid averaged to 55 mgs per litre and 29 mgs of sulphurous acid were found to be present per litre of spirits.

It was thus established that in the great majority of cases high acidity in semi-rectified spirits is due to the presence of sulphurous acid. We all know, that sulphurous acid possesses corrosive properties to a high degree and therefore its presence in power alcohol is particularly objectionable. In fact on analysis products of oxidation of engine parts were found to contain a high percentage of sulphites when that oxidation was due to burning alcohol.

The object of that paper is to examine the theoretical and technical aspects of alcohol production when sulphites are present in the raw material or otherwise when the molasses mashed are by-products in sugar manufacture by a sulpho-defecation process. Analysis of molasses from several sugar factories producing white sugar has shown that on an average the sulphites content of such molasses amounted to about 0.03% expressed as SO_2.

Let us now examine how it is that these sulphites which have resisted decomposition through prolonged boiling in the evaporator and pans are almost completely decomposed in the fermentation vats.

The chemical reactions occurring during the process of fermentation are not straightforward and the equation

$$C_6H_{12}O_6 = 2\,CH_3 \,.\, CH_2 \,.\, OH + 2\,CO_2$$

is approximate and is only meant to represent the gross final effect. Recent theory indicates that before alcohol is produced, several intermediary products are formed, the first being methyl glyoxal.

$$C_6H_{12}O_6 \longrightarrow 2\,CH_3 \,.\, CO \,.\, CH\,(OH)_2$$

On inspection of the structural formula of that compound we immediately recognise its instability for as you notice two hydroxyl groups are attached to the same carbon atom. Therefore if the reaction stopped at that stage methyl glyoxal would be transformed to Pyruvaldehyde

$$2\,CH_3 \,.\, CO \,.\, CH\,(OH)_2 \longrightarrow 2\,CH_3 \,.\, CO \,.\, CHO + H_2O$$

But the reaction does not stop at that stage and pyruvic acid and hydrogen are formed from methyl glyoxal. In fact pyruvic acid has been found to be present in worts.

$$CH_3 . CO . CH(OH)_2 \rightarrow CH_3 . CO . COOH + H_2$$

Pyruvic acid then forms acetaldehyde which reacts with hydrogen to form alcohol.

A graphic representation of the reaction is given

$$\underset{\text{Glucose or Fructose}}{C_6H_{12}O_6} \rightarrow 2\,CH_3 . CO . CH(OH)_2 \quad \text{methyl glyoxal}$$

$$\downarrow$$

$$2\,CH_3 . CO . COOH \quad \text{pyruvic acid}$$

$$\downarrow$$

$$\left.\begin{array}{r} + \underset{\text{hydrogen}}{H_2} \\ \text{acetaldehyde } 2\,CH_3 . CHO \end{array}\right\} \rightarrow \underset{\text{Ethyl alcohol}}{2\,CH_3 . CH_2 . OH}$$

$$+ \underset{\text{carbon dioxide}}{2\,CO_2}$$

However, in the presence of sulphites or sulphurous acid the acetaldehyde formed combines with these substances to form a sulphite aldehyde and the hydrogen formed by the decomposition of methyl glyoxal instead of combinining with acetaldehyde fixes itself on another molecule of methyl gloxal to form glycerin.

A graphic representation of these changes is given

$$C_6H_{12}O_6 \rightarrow CH_3 . CO . CH(OH)_2$$

$$\downarrow$$

$$\boxed{\begin{array}{c} CH_3 . CHO \\ + \\ SO_2 \end{array}} \leftarrow CH_3 . CO . COOH$$

$$\left.\begin{array}{r} + H_2 \\ \rightarrow CH_3 . CO . CH(OH)_2 \end{array}\right\} \rightarrow CH_2 . OH . CH . OH . CH_2 OH$$

Sulphite-aldehydes are unstable compounds and are decomposed during distillation, with the evolution of SO_2.

When rectified spirits are produced, part of the SO_2 is liberated to the atmosphere and the rest remains is solution in head products ; and when rectification is conducted properly the rectified spirits are practically free from SO_2, as I have been able to ascertain at distillery in Mauritius which is equipped to produce rectified spirits. The product turned out by our other distilleries is usually semi-rectified spirits that is a

product showing about 94 to 96 degrees Gay Lussac but which is not free from low boiling impurities. With these columns, it is not possible to obtain SO_2 free alcohol from sulphitation molasses with less than about 20% of heads.

Great embarassment was therefore felt by several distillers and you may well imagine that in those cases faulty setting and relaxing of chemical control resulted in an acid produce.

Mr. R. Avice, however, was able successfully to deal with the difficulty by admitting near to the bottom of the concentration column a dilute solution of sodium carbonate. The SO_2 is thereby completely removed by combination with sodium carbonate. Semi-rectified spirits and head products are practically neutral being free not only of SO_2 but also of fatty acids.

The average amount of carbonate found to be required was one gram per litre of alcohol produced. It is the practice to admit the carbonate solution through the lower fusel oil cock by means of a pipe and funnel providing a head of 15 to 20 feet.

However, the removal of tail products below the admission of carbonate becomes unfeasable unless such products are sent to waste because they usually contain an objectionable amount of solids in solution. In local practice when carbonate is used as neutralising agent, the removal of fusels is discontinued and the good working of the still is thereby impaired. That inconvenience could be remedied by the installation of an appliance patented by Mr. France Giraud. The plant was installed at Mon Désert Distillery some two years ago and has since worked satisfactorily. The distillery processes molasses from raw sugar manufacture and the problem is to neutralize fusel oil which were formerly sent to waste on account of its high fatty acid content. That is obtained by passing the tail products through an alkaline liquor contained in a steam jacketted vessel and condensing the vapours therefrom. About 3% of the total alcohol made is thereby recovered.

If tail products containing solids in solution were passed in the Giraud neutralizer, such products could be recovered and the good working of the still would not be interfered with.

So far as industrial alcohol is concerned so good; but there remains blue spirits and potable spirits to be considered.

In 1942 I have drawn attention to the high acidity usually associated with blue spirits which generally corrode rapidly the domestic metalwares in which they are burnt.

In case the molasses mashed are raw sugar molasses the acidity is due to blue spirits containing tail products of a high fatty acidity, as much as 360 miligrams per litre in cases. That can be remedied by the use of the Girand neutralizer as already laid down. When the molasses mashed are sulpho defecation molasses the head products show a high sulphurous acidity as much as 50 miligrams of SO_2 per litre in cases and tail products a high fatty acidity; that could be remedied by the use of carbonate and of the Giraud neutralizer.

We now come to potable spirits. Rums direct from the still possess a sulphurous acidity which can be titrated with iodine when the molasses mashed are sulphitation molasses. That is of course quite regular as rum comprises tails and heads. However rums known to have been manufactured with sulpho-defecation molasses and which have undergone storage show a high total acid content but does not show even traces of SO_2. Further analysis however proves that they contain sulphuric acid. It appears that when stored in casks sulphurous acid originally present in rum is oxidised to sulphuric acid under what seems to be catalytic influence.

Examination of rums known to have been manufactured from raw sugar molasses showed an average total acidity of 8 milligrams acetic acid per litre of absolute alcohol. Of that total acidity about half was found to be fixed and half volatile.

Rums known to have been manufactured from sulpho-defecation molasses have a wide range of total acidity; from 50 to 150 miligrams total acids expressed as acetic acid were found to be present per litre of absolute alcohol. Of that total acidity about 20 o/o was found to be volatile. The fixed acidity was found to consist almost exclusively of sulphuric acid.

Examination of data showed, further, that rums manufactured from sulpho-defecation molasses had not only a higher fixed acidity but also a higher volatile acidity, exclusive of SO_2. That also is quite regular seeing that in the presence of sulphites, aldehydes are formed in equivalent amount and these aldehydes ultimately give rise to organic acids.

I have to acknowledge the valuable help I have received from Mr. Robert Antoine in connection with the analysis of Rum.

NOTE ON A CASE OF TWIN ARROWS IN A SUGARCANE SEEDLING

G. C. STEVENSON
Geneticist — Sugar Cane Research Station

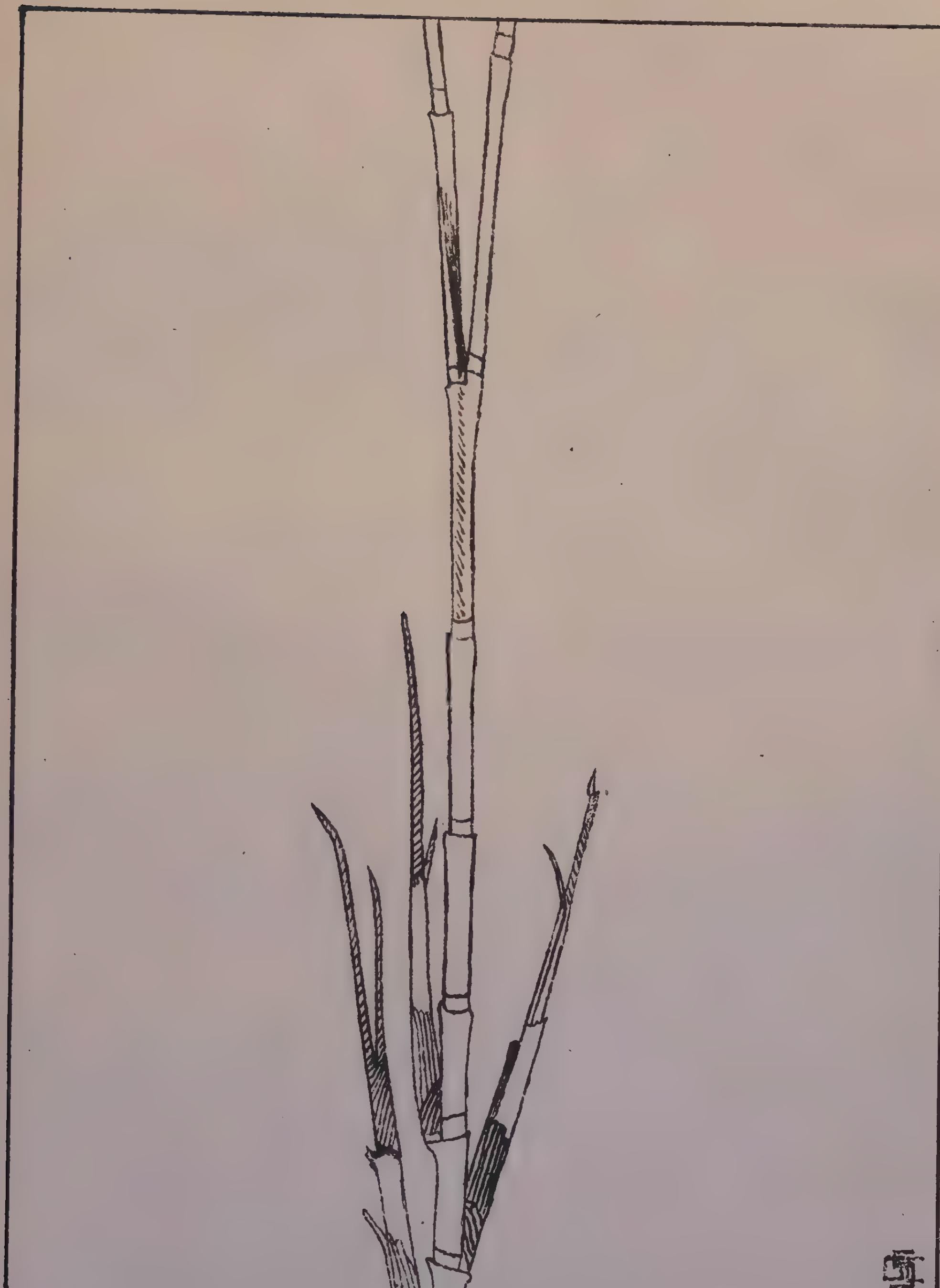
An interesting case of a cane bearing two distinct arrows was found at the Central Experiment Station, Reduit, in June 1944. The cane occurred in a ratoon stool of a seedling from the cross M. 134/22 × M. 243/40, the latter variety being a nobilisation of *S. robustum*. The seedling, therefore, is descended from three *Saccharum* species *S. officinarum*, *S. spontaneum*, and *S. robustum*. The other canes in the stool were normal.

The appearance of the cane is illustrated by Plate 4, and its anatomy near the point of bifurcation by the diagrammatic sketch, made after removal of the leaf-bases. It will be noted that no buds occured on the upper nodes. The cane was not unusual, however, in this respect, for in a normal arrowing cane the upper four or five nodes, supporting the elongated internodes immediately below the arrow stalk, are budless. Bifurcation took place at the penultimate node below the arrows, succeeding an internode which was slightly constricted and grooved. The two branches were unequal in development, one having shorter and thinner internodes and a smaller arrow than the other. The branching systems of the two arrows were dissimilar.

Bifurcation in vegetative canes has frequently been described and illustrated (e.g. Martin, J. P., Proceedings of Fourth Congress I.S.S.C.T. Bulletin. 73, 1933 , and is met with from time to time both in recognized varieties and in seedlings. The writer has, however, not previously seen an example of a cane bearing two arrows, nor is he aware of any published description of such a condition.

PLANCHE IV

Twin arrows of Sugar cane



Bifurcation of sugar cane shoot bearing two arrows.

STATISTIQUES

10. PLUVIOMÉTRIE & TEMPÉRATURE

Pluviométrie (Pouces)

Localités / Mois	Nord							Centre					
	Grand' Baie	Pamplemousses	Pamplemousses (Normale)	Abercrombie	Abercrombie (Normale)	Ruisseau Rose	Belle Vue Maurel	Beau Bois (Moka)	Helvétia	Réduit	Réduit (Normale)	Curepipe*	Curepipe (Normale)†
Mai 1944 ...	0.51	1.19	4.48	0.98	4.44	0.78	0.79	4.34	1.65	0.92	4.24	3.42	9.86
Juin „ ...	2.10	1.10	3.43	0.39	2.13	0.82	2.43	3.37	3.47	1.90	3.11	6.29	7.47

Localités / Mois	Est				Ouest					Sud			
	Centre de Flacq	Camp de Masque	Palmar	G.R.S.E.	Port-Louis	Case Noyale	Beau-Bassin	Beau-Bassin (Normale)	Richelieu	Rose Belle	Riche-en-Eau	Camp Diable	Chemin Grenier
Mai 1944 ...	2.60	5.45	1.58	0.81	0.32	—	0.15	3.64	0.18	4.82	3.39	4.77	3.68
Juin „ ...	3.45	4.92	1.95	3.19	0.27	—	0.72	1.81	0.57	9.71	6.31	5.66	4.98

Température °C

Localités	Abercrombie		Beau-Bassin		Réduit			
Mois	Max.	Min.	Max.	Min.	Max.	Min.	Moy.	Nor.
Mai 1944 ...	28.2	19.2	28.5	17.8	24.2	17.4	20.4	20.6
Juin „ ...	27.3	17.8	26.8	16.4	23.1	16.5	19.5	18.7

* Collège Royal. † Jardin Botanique.

20. YIELD OF MAIZE.
JULY-AUGUST-SEPTEMBER 1943 PLANTATIONS

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Pamplemousses	
Beau Plan	nil
The Mount	25
Rosalie-California	200
Solitude	88
Masilia	420

Average: 78 Kgs./Arpent

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Riv. du Rempart	
Beau Séjour	77

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Flacq	
Beau Champ	74
Constance	230
Teeluck Bros.	137
Ythier Frères	145
Queen Victoria	nil
Bonne Mère	nil
Société Rambarrun	160
Union-Flacq	50
Deep River	53
Madhoo, C.	62
La Lucie	100
Petite Etoile	50

Average: 65 Kgs./Arpent

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Moka	
Sans Souci	57
Rich Fund	150
Ibrahim Cassam & Co.	88
Alma	104
Chantenay	nil
Côte d'Or	nil

Average· 67 Kgs./Arpent.

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Plaines Wilhems	
Réunion	150
Pierrefonds	218
Highlands	175

Average: 133 Kgs./Arpent

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Black River	
Médine	400
Chébel	240
Gros Cailloux	400
Tamarin	213

Average: 300 Kgs./Arpent

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Savanne	
Bel Ombre	48
Bénarès	70
Bel Air	70
Britannia	585
St. Aubin	360
Union Ducray	110
St. Félix	225
Savannah	45
Joli Bois	nil
Terracine	180
Riv. des Anguilles	285

Average: 185 Kgs./Arpent

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Grand Port	
Rose Belle	100
Union Park	22
Constantin	nil
Deux Bras	247
Savinia	214
Mon Trésor	84
Beau Vallon	158
Riche en Eau	150
Ste. Madeleine... ...	nil
Astroea Rochecouste ...	188
Ferney	nil
Anse Jonchée	300

Average : 136 Kgs./Arpent

Summary

Estates	Yield/Arpent Kgs. 12 o/o Moisture
Pamplemousses... ...	78
Riv. du Rempart ...	77
Flacq	65
Moka	67
Pl. Wilhems	135
Black River	300
Savanne	185
Grand Port	133

Weighted Average : Whole Island 128 Kgs./Arpent.

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